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ABSTRACT

This document consists of materials for a six-unit course on employment in the machine shop setting, safety, basic math skills, geometric figures and forms, math applications, and right triangles. The instructor's guide begins with a list of competencies covered in the module, descriptions of the materials included, an explanation of how to use the materials, and information on how the curriculum guide is packaged. Next is a table that associates individual instructional materials in the units with the competencies they teach. The instructional units follow, each of which may include unit objectives, lesson objectives, lesson plans, references, notes to the teacher, information sheets or outlines, transparency masters, handouts, assignment sheets, job sheets, unit tests, and answers to tests. (CML)

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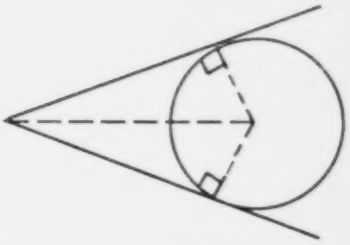
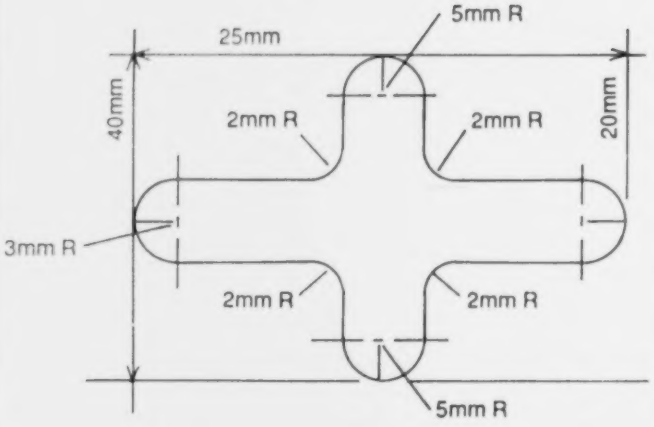
MACHINE SHOP CURRICULUM

INSTRUCTOR'S GUIDE

MODULE 1: Machine Shop Orientation and Math





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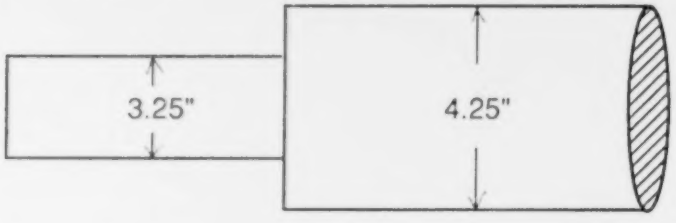

CE 054 447

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MACHINE SHOP

Module 1: Machine Shop Orientation and Math

by
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1989

Instructor's Guide
Catalog No. 70-6171-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This Machine Shop guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future machine shop curriculum modifications will begin with this guide. The machine shop field is undergoing considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
Industrial Education
Department of Elementary and Secondary Education

Charles "Chuck" Waibel, director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGMENTS

This Machine Shop guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the machine shop competency profile developed by industry and education professionals in the state.

Appreciation is given to the writers (Charlie Walden, Jack Nobles, Dwight Crosswhite, Donna Curtis, Don Marquardt, Bill Daniel, Mel Gage and Jr. Cagle) for their technical expertise. Catherine Smith of Dodge Art Works, Columbia, created a large portion of the guide's artwork.

These industry representatives and educators contributed to the guide as members of the advisory committee.

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Phyllis Miller and Dan Stapleton, assistant directors
Donna Curtis and Lori Holliday, word processors
Julie Bishop, student assistant - clerical
Wei Li, graduate assistant

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Unit VI: Right triangles 189

COMPETENCIES ADDRESSED IN THIS MODULE

A. Orientation to Machine Shop

1. Operate safely in the workshop
2. List machine shop safety rules and regulations
3. Identify characteristics of a machinist
4. Inspect work area for safe work environment

B. Performing Mathematical Calculations

1. Convert common fraction to decimal fraction and vice versa
2. Calculate tap drill size with formula and charts
3. Convert customary measurements to metric and vice versa
4. Use calculator to perform mathematical operations
5. Calculate amount of stock required
6. Calculate part and feature dimensions and locations
7. Convert revolutions per minute (rpm) to surface feet per minute (sfpm)
8. Calculate feeds and speeds
9. Calculate tapers for machine set-up
10. Calculate sine-bar set-up
11. Perform angular and simple indexing calculations
12. Calculate measurements of right triangles
13. Calculate plane geometry/math applications

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT I: EMPLOYMENT

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: EMPLOYMENT OUTLOOK

   a. Information outline

   b. Handout

      HO 1.1: Trade associations and labor unions
      HO 1.2: Sample schedule for tool and die maker apprentices

   c. Assignment sheet

      AS 1.1: Machinist occupations

   d. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Dictionary of Occupational Titles. 4th ed. Washington, DC: U.S. Department of Labor, Employment and Training Administration, 1977.

2. Occupational Outlook Handbook. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, 1988.

3. Bell, John A., and Lonny D. Garvey. Opportunities in the Machine Trades. Lincolnwood, IL: VGM Career Horizons, 1986.

B. Curriculum guides

1. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The teacher could share personal career experiences.

2. A panel of several successful machinists employed in various jobs could be invited to the class to describe their jobs, how they were trained, their career paths, what they like and dislike about their jobs, what advice they would give to beginning machinists and what they feel are important characteristics for a potential machinist.

B. Suggested student activities

1. Students could be assigned to do a brief interview with a machinist. The students should be instructed to have specific questions relating to careers written down prior to the interview. The students could report briefly to the class on what they learned or turn in a written report.

2. Have students check job listings in major metropolitan newspapers.

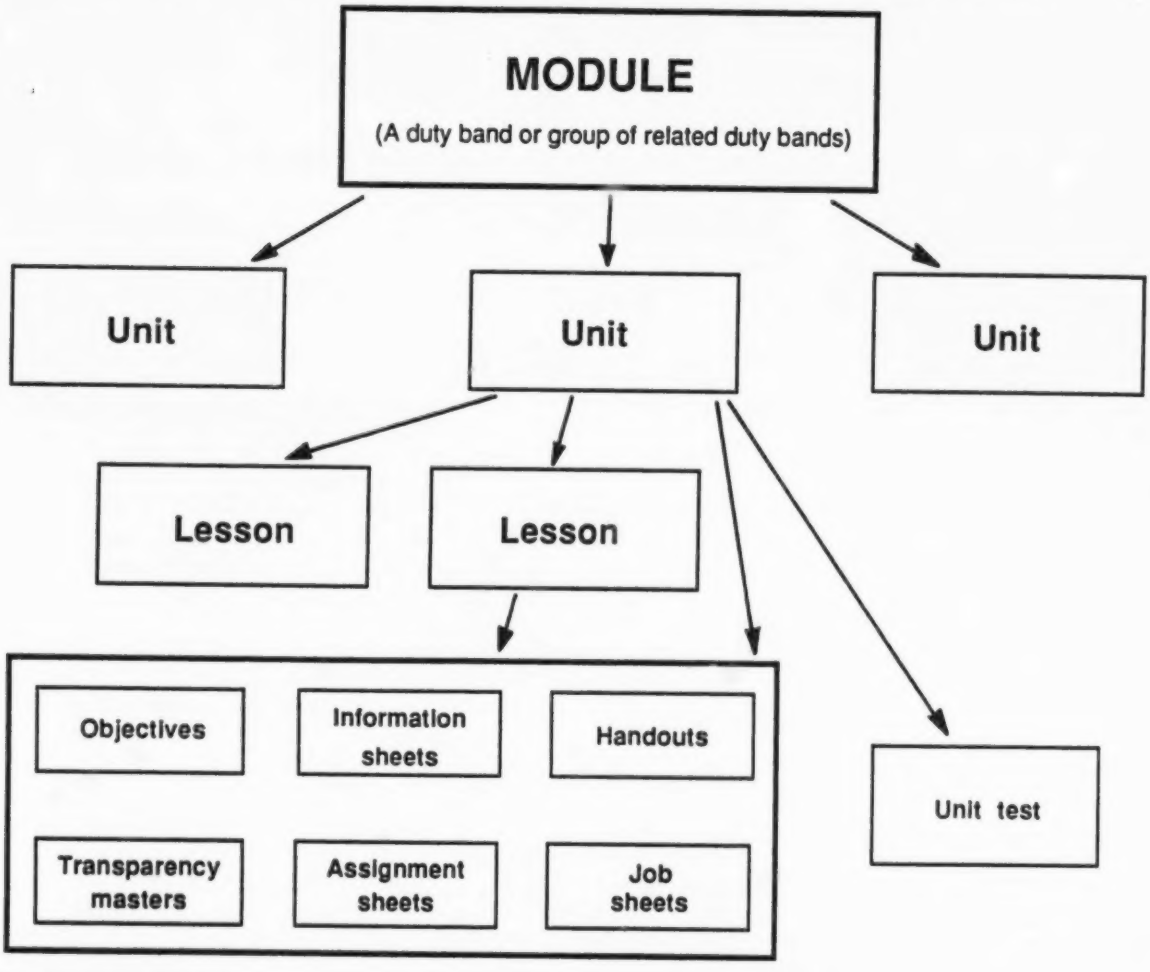
3. Students could write for additional information from trade associations and labor unions. (See HO 1.1 for addresses.)

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of Instruction

This Machine Shop guide contains eight modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency Profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- 3 = **Mastery** - can work independently with no supervision
- 2 = **Requires supervision** - can perform job completely with limited supervision
- 1 = **Not mastered** - requires instruction and close supervision
- N = **No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage or bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet

assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Machine Shop guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all eight modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 1: MACHINE SHOP ORIENTATION AND MATH

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
A1	II 1.3,1.5,1.7,2.2, 3.1,3.2,3.4-3.7		II 3.1,3.2	II 3.1		II 2,4-8,10,14,15, 17-21,28-30	
A2	II 1.1,1.2-1.4,1.8, 3.3	II 1.1		II 1.1		II 1,3,9,16,23-27	
A3	I 1.1-1.4		I 1.1,1.2	I 1.1		I 1-12	
A4	II 1.6,2.1,2.3,2.4		II 2.1	II 2.1		II 11-13,22,31-33	
B1	III 1.1,1.2		III 1.1	III 1.1		III 1,3,4,9,11-13	
B2	V 1.1-1.3		V 1.1	V 1.1		V 1,7-11	
B3	III 2.2		III 2.1	III 2.1		III 18,19,23-25	
B4	III 1.3,3.1-3.3			III 3.1		III 2,6,7,26-30	
B5	III 1.2,1.3			III 1.1, II 2.1		III 8,10,17,20,21	III pretest
B6	III 1.4,2.1, VI 1.6			IV 2.2, VI 1.3		III 5,14-16,22, VI 14-17	
B7	V 4.2			V 4.1			
B8	V 4.1,4.3,4.4					V 4,17-20	
B9	V 2.1,2.4, VI 2.1			V 2.1, VI 2.1		V 2,6,13, VI 13	
B10	VI 2.2			VI 2.2		VI 10-13,19-20	
B11	V 3.1,3.2			V 3.1		V 3,14-16	
B12	VI 1.1-1.6	VI 1.1	VI 1.1,1.2	IV 1.1, VI 1.1,1.2		VI 1-9	
B13	IV 1.1-1.4,2.1-2.9, V 2.2,2.3		IV 2.1,2.2	IV 1.1,2.3, V 2.1		IV 1-22, V 5,12	

MODULE: MACHINE SHOP ORIENTATION AND MATH
UNIT I: EMPLOYMENT

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe employment opportunities in the machine trades and identify the characteristics of a successful machinist. This knowledge will be evidenced by completion of the assignment sheet and unit test to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Describe machine trade occupations.

1.2 Describe the employment outlook for machine trades in the next decade.

1.3 Identify employers of machine workers.

1.4 Identify characteristics of a successful machinist. (competency A3)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT I: EMPLOYMENT

LESSON 1: EMPLOYMENT OUTLOOK

I. Machining occupations **(HO 1.1)**

A. All-around machinist

1. Sets up and uses a variety of tools and machines such as the lathe, milling machine, borer, grinder, drill press and hand tools such as scrapers and files
2. Fits and assembles parts to fabricate or repair machine tools
3. Maintains industrial tools; diagnoses malfunctions of machines and determines need for adjustment or repair
4. Reads, uses or develops blueprints, sketches or machine part specifications
5. Uses measuring devices such as verniers, height gauges and gauge blocks and micrometers
6. Heat treats machined parts and verifies accuracy by the use of hardness testers

B. Some machinist occupations requiring additional training or experience

1. Instrument mechanic--responsible for the construction, installation, maintenance and calibration of mechanical and electrical test instruments and gages
2. Toolmaker--specialist in the making, operating and repairing of precision production tools
3. Diemaker--toolmaker who has specialized in the making of punches and dies
4. Set-up person--readies machines for production, trains the operator and checks the product against specifications
5. Moldmaker--specialist in building tools that shape plastic or soft metals while in a liquid state (requires additional knowledge of plastics and thermodynamics)
6. Specialized machine operators--sets up, operates and maintains a specific machine

   Examples: milling machine operators, computerized numerical control machine operators or programmers
7. Skilled inspectors and quality-control persons--check aspects of production (may require additional knowledge of statistics)
8. Supervisor or foreman--manages human resources using leadership skills
9. Planner or production manager--supervises production, writes operation sheets, specifies operations, machines or tools

C. Journey worker machinist--has completed a federally certified apprenticeship **(HO 1.2)**

NOTE: For more information on setting up an apprenticeship, contact the Bureau of Apprenticeship and Training, U.S. Department of Labor. (In Missouri: 210 N. Tucker Blvd., St. Louis, MO 63101 Telephone 314/425-4522)

1. An apprenticeship includes organized on-the-job training and classroom instruction for the acquisition of specific skills.

   a. Consists of 8,000 hours of employment over a four-year period, including 168 hours yearly of related and supplemental classroom instructions

   b. For high school graduates (or equivalent) between 18 and 26 years of age

   c. Credit given for veteran's status or previous experience

   d. Includes a probationary period during the first 500 hours

2. Apprenticeship offers several important advantages.

   a. Opportunity to develop employability

   b. Wage guarantee with regular increases while serving the apprenticeship (50-90% of current journey worker wages)

   c. Recognition as a skilled worker upon completion

D. Semi-skilled--requires some skill or on-the-job training

1. Production machine operators--worker trained in the operation of a single machine tool

2. Parts assemblers or inspectors

3. Helpers to skilled workers

E. Mechanical engineering technician--develops and tests machinery and equipment, applying knowledge of mechanical engineering technology (The technician usually has a minimum of two years of college.)

F. Mechanical technologist--works closely with an engineer and can act as liaison between the engineering office and the machine shop office (requires special training)

G. Professions

1. Teacher or instructor

   a. Requirements can include achievement of a certain education level (a minimum of a high school diploma for a teacher of shop skills), a specific number of years of experience and/or successful completion of an examination.

   b. Opportunities for experienced machinists to teach are expected to continue to increase as the funding and demand for vocational training increases.

2. Engineer

   a. Education--usually has completed a minimum of a B.A. or B.S. degree (includes general education and a curriculum emphasizing mathematics, sciences and the application of this knowledge in a specialized area)

b. Industrial--designs methods for efficient production

c. Mechanical--designs and oversees construction and operation of power plants, engines and machines

d. Chemical--adapts chemical processes to large-scale production

II. Employment outlook

A. Present

1. Estimated employment of machinists in 1986: 378,000

2. Jobs are most plentiful in metropolitan areas where factories are located.

B. Little change is expected in the employment of machinists through the year 2000.

1. Employment growth is limited by the growing use of nonmetal parts, increasing foreign competition and the continuing use of computer-controlled machine tools.

2. Highly-skilled maintenance machinists will be needed to prevent costly breakdowns in highly mechanized plants.

3. Increasingly sophisticated applications of computerized numerical control machines and robotics will require persons with special skills and knowledge.

C. Earnings have compared favorably with those of other skilled workers, according to data from the U.S. Bureau of Labor Statistics.

1. In 1986, median (middle) weekly earnings were about $420. Most earned between $310 and $515 weekly.

2. Machinists in metropolitan areas have greater estimated average hourly earnings.

3. Average hourly earnings of machinists vary widely according to locale.

4. Most machinists have pension plans, paid vacations, holiday and sick leave, and medical insurance supplemented (in part or totally) by employers.

5. Benefits can include profit-sharing plans and supplemental piece-rate incentives in some types of companies.

III. Employers of machine workers

A. Types of shops

1. Mass-production shops produce only one item, such as an engine.

2. Job shops do general machine work and fitting on any type of machinery.

3. Maintenance shops repair and maintain machines.

4. Small, independent businesses

5. Closed versus open shops

a. Closed shops require union membership for employment.

b. Open shops do not require employees to be union members.

B. Some industry types

1. Automotive
2. Civil service (government)
3. Aerospace and aircraft
4. Defense
5. Farm machinery
6. Factories producing textiles, paper, chemicals, glass, etc.
7. Marine
8. Energy production
9. Research and development laboratories

IV. Requirements to be a successful machinist

A. Interests and aptitudes

1. Likes to build and repair all kinds of devices
2. Likes creative and challenging work
3. Manual dexterity

B. Safety conscious; awareness of time and material waste

C. Personal attributes

1. Temperamentally suited to do highly accurate work requiring concentration and physical effort in working conditions that can be noisy
2. Patient and able to get along well with co-workers and supervisors
3. Ability to do work without close supervision
4. Enthusiastic and proud of work
5. Neat and orderly

TRADE ASSOCIATIONS AND LABOR UNIONS

Associations are valuable as sources of industry and employment information. They provide numerous other benefits to members, potential members and the public.

Trade associations

National Tooling and Machining Association (NTMA)
9300 Livingston Road
Ft. Washington, MD 20744

National Machine Tool Builders Association
7901 Westpark Drive
McLean, VA 22102

The National Association of Manufacturers
1776 F Street NW
Washington, DC 20006

National Association of Trade and Technical Schools
2021 K Street NW, Suite 315
Washington, DC 20006

Tooling and Manufacturing Association
1177 S. Dee Road
Park Ridge, IL 60068

Labor unions

International Association of Machinists and Aerospace Workers
1300 Connecticut Avenue NW
Washington, DC 20036

International Union of Allied Industrial Workers of America
3520 West Oklahoma Ave.
Milwaukee, WI 53215

International Union of Electronic, Electrical, Technical Salaried and Machine Workers
1126 16th St.
Washington, DC 20036

SAMPLE SCHEDULE FOR TOOL AND DIE MAKER APPRENTICES

	Approx. hours
Tool room helper	500
General clean-up	
Shaping	
Cut-off saw	
Drilling	
Surface grinding	
Die repair department	1000
Cleaning, disassembly and assembly of production die cast dies	
Minor repairs	
Tool room - grinding	700
Drills (i.e. hand and machine)	
Milling cutters	
Carbaloy tip grinding	
Form tools	
Gage grinding	
Tool room - machinery	500
Contour sawing and filing	
Milling machine	
Lathe work (to include pistons and cold chambers)	
Jigs, fixtures and gages	500
Boring, drilling, tapping and assemble fixtures	
Special and production gages	
Trim dies	700
Layout and inspection	
Bench work on die cast dies and mold dies	3428
Layout	
Hand filing	
Polishing and fitting	
Model making	
Template work	
Numerical engraving	
Die tryout	
Die sample inspection and correction	
Heat treatment	
Welding	
TOTAL	7328
Related instruction	672
	8000

SCHEDULE OF RELATED INSTRUCTION FOR TOOL & DIE MOLD MAKER

	Hours
Use, care and reading of tools	24
Machine tool operation theory	66
Blueprint reading	72
Trade technology	18
Shop mathematics	210
Strength of materials	24
Shop drawing	76
Metallurgy and heat treatment	36
Tool and die design	74
Use of Machinery's Handbook	36
Social economics	18
Safety and first aid	18
TOTAL	672

Source: Department of Labor

MACHINIST OCCUPATIONS

1. Define machinist.

2. Choose a machinist occupation requiring additional skills or training. Find out as much as possible about this occupation, including job descriptions, training or skills needed, employment opportunities, pay scales, etc. (Use references listed; contact trade associations; use local library resources; talk to persons working in the occupation.)

3. List as many different employers of machine workers as possible.

4. What are the interests and aptitudes of a successful machinist?

5. List four personal attributes of a successful machinist.

   a.

   b.

   c.

   d.

Circle the word which best completes the statement.

6. An (open/closed) shop requires union membership for employment.

7. Journey worker machinists have generally completed a(an) (college degree/apprenticeship).

8. Through the year 2000, (increased employment/little change in the number of positions) is expected for machinists/tool- and diemakers.

9. Job shops (produce only one item/do general machine work).

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency A3.

ANSWERS TO AS 1.1

1. Evaluated by instructor

2. Evaluated by instructor

3. At least eight of the following:
   Mass production shops
   Job shops
   Maintenance shops
   Small, independent businesses
   Automotive industry
   Civil service (government)
   Aerospace and aircraft industry
   Defense industry
   Farm machinery production
   Factories producing textiles, paper, chemicals, glass, etc.
   Marine industry
   Energy production
   Research and development laboratories

4. Likes to build and repair all kinds of devices, likes creative and challenging work, has manual dexterity

5. Any four of the following:
   Temperamentally suited to do highly accurate work requiring concentration and physical effort in working conditions that can be noisy
   Patient and able to get along well with co-workers and supervisors
   Can do work without close supervision
   Enthusiastic and proud of work
   Neat and orderly

6. Closed

7. Apprenticeship

8. Little change in the number of positions

9. Do general machine work

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT I: EMPLOYMENT

UNIT TEST

Match occupational descriptions with titles.

____	1.	Trains operators; specializes in getting machines ready for production	a.	Apprentice
____	2.	Specializes in the making of punches	b.	All-around machinist
____	3.	Specializes in building tools that shape materials in their liquid state	c.	Instrument mechanic
____	4.	Person who can set up, operate, maintain and repair a variety of machine tools	d.	Diemaker
____	5.	Person responsible for the construction, maintenance and calibration of mechanical and electrical test instruments	e.	Set-up person
____	6.	Uses leadership skills in the management of human resources	ab.	Supervisor or foreman
____	7.	Works with the engineer and can act as the liaison between the engineering office and the machine shop office	ac.	Mechanical technologist
____	8.	Professional who designs, oversees construction and operation of power plants, engines and machines	ad.	Mechanical engineer
			ae.	Moldmaker

Choose the option which answers the question or completes the statement.

____ 9. Which describes a machinist'semployment outlook?

a. Most plentiful in rural areas
b. Expected to remain about the same through the year 2000
c. Expected to increase more slowly in the area of maintenance of highly mechanized equipment
d. Unaffected by factors such as foreign competition and technological developments
e. All of the above

____ 10. Which is true of the earnings of machine workers?

a. Compare favorably with those of other skilled workers
b. Vary according to locale
c. Can include income from supplemental piece-rate incentives
d. Frequently include fringe benefits
e. All of the above

___ 11. Where are machinists usually employed?

a. In a wide variety of industries
b. Only by the automotive and aerospace/aircraft industries
c. In job shops which produce only one item such as an engine
d. Most frequently in rural areas
e. None of the above

___ 12. Which of the following is <u>not</u> an important interest or aptitude of a machinist?

a. Likes creative and challenging work
b. Likes to build all kinds of devices
c. Manual dexterity
d. Ability to organize groups of people
e. All of the above

ANSWERS TO UNIT TEST (A3)

1. e
2. d
3. ae
4. b
5. c
6. ab
7. ac
8. ad
9. b
10. e
11. a
12. d

NOTE: The number in parentheses indicates the competency this test evaluates.

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT II: SAFETY

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe machine shop safety rules, conditions for a safe work environment, fire safety rules and prevention, and first-aid procedures. This knowledge will be evidenced by achieving a specified score on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match safety terms and definitions.

1.2 Identify OSHA employer and employee expectations.

1.3 Complete statements concerning general safety rules.

1.4 Complete statements concerning eye safety rules.

1.5 Complete statements concerning personal safety rules. (competency A1)

1.6 Complete statements concerning good housekeeping rules. (competency A4)

1.7 Complete statements concerning the safe use of equipment and tools.

1.8 Match safety color codes and signs with uses. (competency A2)

2.1 Select true statements concerning fire safety rules.

2.2 Identify the three components of the fire triangle. (competency A1)

2.3 Identify the classes of fires and the methods of extinguishing them.

2.4 Describe uses and operation of various types of fire extinguishers. (competency A4)

3.1 Match first aid terms and definitions.

3.2 Complete statements concerning general guidelines for first aid.

3.3 Identify methods of recognizing and treating shock. (competency A2)

3.4 Identify first aid treatment for injuries.

3.5 Identify first aid treatment for eye injuries.

3.6 Identify the types of bleeding and methods to control it.

3.7 Identify first aid treatment for electrical shock. (competency A1)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT II: SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: SAFETY RULES AND REGULATIONS

   a. Information outline

   b. Transparency master

      TM 1.1: Safe lifting tips

   c. Assignment sheet

      AS 1.1: Machine shop safety

   d. Answers to assignment sheet

2. Lesson 2: FIRE SAFETY

   a. Information outline

   b. Handout

      HO 2.1: Fire safety

   c. Assignment sheet

      AS 2.1: Fire prevention and safety

   d. Answers to assignment sheet

3. Lesson 3: FIRST AID

   a. Information outline

   b. Handouts

      HO 3.1: Pressure points
      HO 3.2: Electrical shock and first aid

   c. Assignment sheet

      AS 3.1: First aid

   d. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

B. Curriculum guide

1. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Guest speakers might include the safety or risk management officer from a local company or a representative of the fire department.
2. Contact an area Red Cross chapter for first-aid teaching materials such as the Basic Aid Training Kit (BAT). This illustrated kit includes approved first-aid procedures for the class.
3. Invite a Red Cross representative to speak to the class about safety and first aid procedures.
4. Have students participate in practice fire, safety and first aid drills.

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT II: SAFETY

LESSON 1: SAFETY RULES AND REGULATIONS

I. Terms and definitions

A. Safety--state of being free from danger, risk or injury

B. Accident--any suddenly occurring, unintentional event which causes injury or property damage

C. OSHA--Occupational Safety and Health Administration; federal agency which is concerned with providing safe, sanitary working conditions

II. OSHA regulations

A. Employer requirements

1. Provide a hazard-free work place and comply with occupational safety and health standards.

2. Inspect job sites to make sure they meet safety standards.

3. Use appropriate color-coded signs to warn of danger.

4. Keep required records of work-related injuries and post an annual summary in February of each year.

5. Report to OSHA within 48 hours any accident that is fatal or results in the hospitalization of five or more workers.

6. Post in a prominent place a poster which informs workers of rights and responsibilities (such as OSHA's #2203).

B. OSHA employee expectations

1. Read the OSHA poster and comply with its standards.

2. Follow employer safety and health rules and wear prescribed clothing or protective equipment on the job.

3. Report hazardous conditions to a supervisor.

4. Report all job-related injuries to a supervisor, seeking prompt treatment if required.

5. Report to OSHA, in a responsible manner, any hazardous working situations that you feel the employer has not attended to properly.

III. General safety

A. Conduct and attitudes

1. Safety is the personal responsibility of <u>every</u> individual <u>all of the time</u>.

2. Safety rules and concerns need to be learned so well that a person can react automatically in even dangerous situations.

3. Good work habits such as promptness, regular attendance, cooperation, reliability, good personal hygiene and patience contribute to both success and safety.

B. General safety rules

1. Never do practical jokes, participate in horseplay, shove, run or throw objects in the shop area.

2. Obey all posted signs.

3. Do not drink alcoholic beverages or use drugs on the job. Do not show up for work with a hangover.

CAUTION: Even in the hangover stage, alcohol impairs judgment and endangers the worker and co-workers. Drugs are both physically and psychologically damaging.

IV. Eye safety rules

A. Always wear specified eye protection.

FORESIGHT IS BETTER THAN NO SIGHT
WEAR SAFETY GLASSES
THINK TWICE AND ACT ONCE

Credit: Davidson, Glenn D. Tool Grinding and Sharpening Handbook. New York: Sterling Publishing, © 1985 Welliver & Sons. Reprinted by permission.

1. Wear safety glasses for any operation involving drilling, lathe work, milling, sawing or grinding and any other machine-tool operation or bench work. (A face shield may also be required.)

NOTE: Safety glasses should meet both industry and OSHA specifications.

2. Wear a proper face shield when the job requires it.

a. In the presence of molten metals, molten case hardening salts or sparks of any kind

b. For heat treating operations or furnace work

c. When using any corrosive or explosive materials

3. For hygienic reasons, it is best to have one's own personal eye protective equipment. (If it is necessary to share goggles or glasses, the equipment should be thoroughly cleaned and disinfected before changing users.)

B. Contact lenses should not be worn in any shop or industrial area for the following reasons:

1. Some gases, vapors and other materials that will harm the eyes can be absorbed by some contact lenses.

2. Dusts and other small particles, when trapped under contact lenses, can harm the eyes or can cause a distraction that could expose the worker or co-worker to other dangers.

3. Electric arcs can cause contact lenses to stick to the eyes, causing serious injury when lenses are removed.

V. Personal safety rules

A. Clothing

1. Wear neat, clean clothing or aprons appropriate to the job being performed.

2. Loose-fitting clothing and loose clothing parts are safety hazards.

a. Wear short-sleeved garments or roll up long sleeves when working around moving machinery.

b. Remove sweater or coat.

c. Do not wear clothing that has dangling parts, torn pockets or other parts that could present a hazard.

d. Tie shop aprons in the back to keep the strings away from the machine.

e. Remove neckties when working with machines.

3. Remove rings, watches, bracelets, necklaces and other jewelry when working with machines.

4. Proper protective clothing (gloves, jackets, pants, shoe guards, etc.) is mandatory when working with furnaces and hot or molten materials.

5. Wear gloves only when appropriate to do so. (Rubber gloves should be worn when using acids, for example.)

6. Wear shoes that cover the entire foot at all times. Shoes should be non-skid, well-insulated, hard-toed and clean.

B. Hair

1. It is best to keep hair short.

2. Long hair must be tied back or protected by a small cap when operating rotating equipment.

C. Wear ear protectors when working under noisy conditions to prevent ear damage.

D. Back

1. Get help when you cannot safely handle material to be lifted or carried. Consider weight, size and shape, and your physical ability to handle the load.

2. Lift materials properly. **(TM 1.1)**

a. Place feet close to the object to be lifted and keep them 8-12 inches apart for good balance.

b. Bend knees to a comfortable degree; get a good hand hold; use both leg and back muscles to begin the lift.

c. Lift the load straight up, smoothly and evenly, while pushing with the legs; keep the load as close as possible to the body.

d. Lift the load into carrying position, making no turning or twisting movements until the lift is completed.

e. Turn your body with changes of foot position while visually checking the path of travel to make sure it is clear.

f. Set the load down by using leg and back muscles together; slowly lower the load by bending your knees; release your grip only after the load is securely positioned.

g. When lifting or carrying with another worker, make sure that the load is equally distributed. Carry long objects at the same level and on the same side of the body.

3. Use hoists or other lifting devices when provided.

VI. Maintaining a clean, orderly shop

A. Arrange machinery and equipment to permit safe, efficient work practices and ease in cleaning.

B. Keep the floor clear of chips, slippery substances and other spills.

C. Safely stack or store materials, tools and supplies in their proper places.

D. Clean machinery thoroughly when the work is finished.

E. Keep working areas and work benches clear and free of debris and other hazards.

F. Keep aisles, traffic areas and exits free of materials, objects and debris.

G. Dispose of combustible materials properly or store them in approved containers.

H. Store oily rags in self-closing or spring-lid metal containers.

I. Keep sufficient brooms, brushes and other housekeeping equipment readily available.

VII. Equipment and tool use

A. Equipment operation

1. Do not operate any machine before receiving instructions on its correct and safe operation from a qualified instructor.

2. Only one operator at a time should control a machine.

3. Turn off the power before leaving machinery.

4. Operate machinery only when existing safety equipment and guards are securely in place and working properly.

5. Make certain power is off and all other specified safety procedures are followed before cleaning, oiling or adjusting a machine.

6. Always keep hands and body away from all moving parts.

7. Never use hands or any body part to brake a machine to a stop.

B. Tool use

1. Use the right tool for the right job.

   Example: Do not use files as hammers.

2. Turn in defective tools for replacement.

3. Store tools in tool boxes or other provided places when not in use.

4. Do not put tools or small objects such as screws in the mouth.

5. Keep hand tools sharp, clean and in safe working order.

6. Use vises and clamps when needed to hold all tools and materials securely.

C. Electrical safety

1. Operate electrical equipment only after receiving proper instructions.

2. Do not touch live electrical parts with bare skin.

3. Handle electrical parts with dry gloves and clothing.

   NOTE: To prevent harmful body shocks, keep hands, feet and clothing dry. Use a dry board or rubber mat when water, moisture or perspiration cannot be avoided.

4. Operate equipment within its rated capacity.

5. Know cable loads and use cables within current capacities.

6. Replace worn or bare cables to prevent electrical shock or damage to equipment. Cables can be taped if the tape has an electrical resistance that is equal to that of the original insulation.

7. Make sure all cable connections are tight; loose connections could cause overheating of cables and electrical terminals.

8. Machines must be installed according to national and local electrical codes.

9. Adjustments or repairs should be done only by authorized, knowledgeable persons. Make adjustments or repairs to electrical equipment only after all power has been disconnected or the electrical breaker has been turned off.

10. Know where all emergency shut-down switches are located.

11. Properly ground all electrical equipment and tools to prevent injury to the operator.

D. Do not attempt to move or use gas cylinders without knowing safe handling procedures.

VIII. Safety color codes, signs and uses

A. Safety color codes

1. Green--applied to nonhazardous parts of equipment and machine surfaces, nameplates and bearing surfaces; designates location of safety and first-aid equipment and supplies

2. Yellow--designates caution; found on operating levers, wheels, handles and hazardous areas which can cause stumbling, snagging, falling or tripping

3. Orange--designates dangerous parts of equipment which can cut, crush, shock or otherwise injure; applied to electrical switches, interior surfaces of doors, fuses and electrical power boxes, and movable guards and parts

4. Red--applied to buttons or levers of electrical switches used for stopping machinery and to all pieces of equipment that are fire hazards (such as gasoline cans)

   NOTE: Red is also used to identify fire-fighting equipment and its location, fire alarms, fire axes and emergency exits.

5. Blue--used to designate caution against starting equipment being repaired or that is defective (A blue tag should be lettered "Out of Order".)

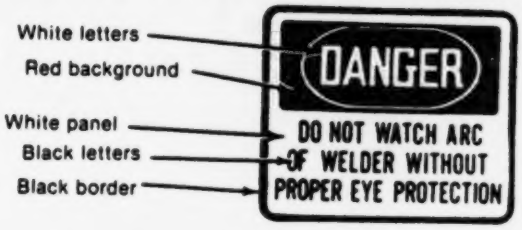
6. Ivory--applied to label edges, vise jaws and tool rest edges to reflect light, helping to show tool and equipment moving edges more clearly

7. Black on yellow--applied to an area where radiation is a hazard

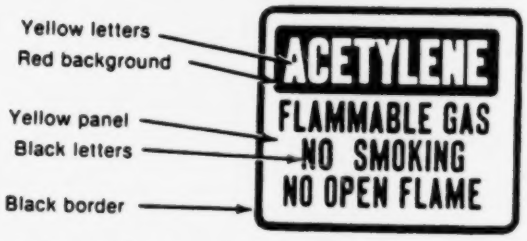
8. Black, white and yellow--used singly or in combination to identify traffic flow and location of housekeeping supplies; applied to floors for safety lanes

B. Accident prevention signs, colors and uses

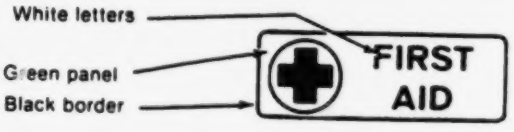
1. Danger signs--used where an immediate hazard exists; colors are red, black and white



2. Caution signs--used to warn against potential hazards or to caution against unsafe practices; colors are yellow and black

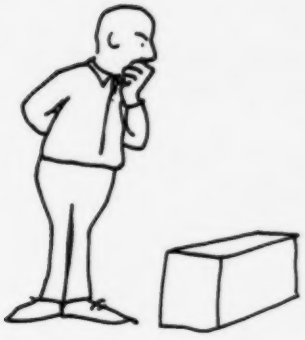


3. Safety instruction signs--used for general instructions and suggested safety measures



SAFE LIFTING TIPS

A.



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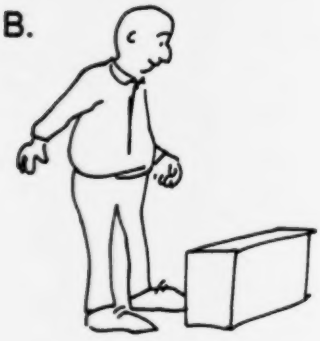


C.

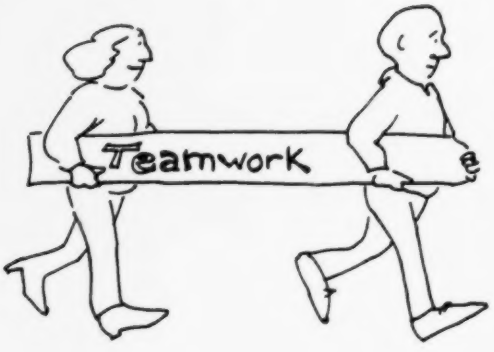
D.

E.

F.

G.

H.



MACHINE SHOP SAFETY

Circle the words that best complete each statement or rule.

1. Long hair must be (cut off/tied back or confined to a cap) when operating rotating equipment.
2. Contact lenses (should/should not) be worn in machine shops.
3. Wear (short-/long-) sleeved garments when working around moving machinery.
4. (Bend over, keeping knees straight/Bend your knees) when picking up a heavy load.
5. Do not drink (alcohol/coffee) while on the job.
6. Clean up spills (at the end of the day/immediately).
7. (Light/Protective) clothing is mandatory when working with furnaces.
8. Store oily rags in (cardboard barrels/spring-lid metal containers).
9. Operate equipment and use cables within (a certain time/their rated capacities).
10. Make sure all cable connections are (tight/loose).

Indicate which type of eye protection is required for each of the following types of work.

11. While using molten metals:
12. Furnace work:
13. Milling:
14. While using corrosive materials:
15. Lathe work:

Indicate the meaning of each of the following color codes.

16. Yellow:
17. Red:
18. Orange:
19. Green:
20. Blue:
21. Black on yellow:

ANSWERS TO AS 1.1 (A3)

1. Tied back or confined to a cap
2. Should not
3. Short
4. Bend knees
5. Alcohol
6. Immediately
7. Protective
8. Spring-lid metal containers
9. Their rated capacities
10. Tight
11. Face shield
12. Face shield
13. Safety glasses
14. Face shield
15. Safety glasses
16. Caution
17. Electrical switches, fire hazards, equipment or exits
18. Dangerous parts of equipment which can cut, crush, shock or injure
19. Nonhazardous parts, location of safety and first-aid equipment
20. On tags indicating "Do not start"
21. Radiation hazard

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT II: SAFETY

LESSON 2: FIRE SAFETY

I. Safety rules

A. Immediately report any indications of a potential fire hazard.

(Examples: The sound of wires shorting even though they can't be seen, a light that blinks on and off, and the smell of smoke even when a flame is not apparent)

B. Know the location and proper operation of fire extinguishers; make sure that they have been checked recently.

C. Know the location of the nearest telephone and make sure that the emergency number is clearly visible on the phone.

D. Know the procedure for evacuating the building and the location of all fire exits.

E. Smoke only at authorized times and in authorized areas; make sure that cigarette butts are completely extinguished and properly discarded.

F. Examine materials and equipment around the work place to determine what fire types might occur. Make sure that the correct fire extinguishers for these fire types are available.

G. Isolate combustible materials in fire-resistant areas.

H. Dispose of wastepaper, rags and other combustible materials in the containers provided specifically for them.

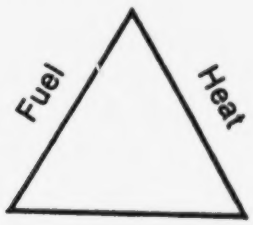
I. Conduct fire drills at regular intervals to make sure that the alarm can be heard over shop noises and that everyone knows evacuation routes, exits and assembly points.

II. To produce or maintain a fire, <u>all three</u> components of the fire triangle must be present at the same time.

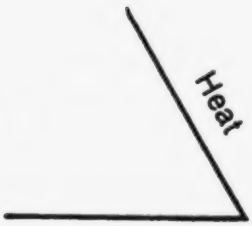
A. Fuel--any combustible material

B. Heat--enough to raise the fuel to its ignition temperature

C. Oxygen--needed to sustain combustion



Oxygen



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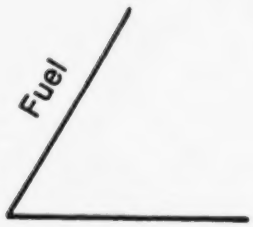
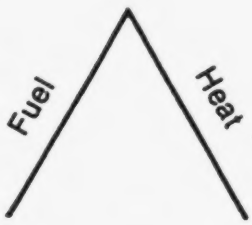


Oxygen



III. Fire types or classes **(HO 2.1)**

A. Class A fires

1. Occur in ordinary combustible materials (wood, rags, paper and rubbish)
2. Put out by lowering the temperature using a water or water-based extinguisher

B. Class B fires

1. Occur in flammable liquids such as gasoline, oil, grease, paints and thinners
2. Put the fire out by smothering it. Cover the entire flaming liquid surface.

C. Class C fires

1. Occur in or near electrical or electronic equipment (motors, switchboards, electrical wiring)
2. Shut off the power as quickly as possible. Use a nonconducting extinguishing agent (not water) to avoid receiving an electrical shock.

D. Class D fires

1. Occur in combustible metals (powdered aluminum and magnesium)
2. Fire extinguishers are not effective. Smother with dry sand, dirt, salt or soda ash.

IV. Types, uses and operation of fire extinguishers **(HO 2.1)**

A. Water

1. Used for class A fires only

2. Operate stored-pressure types by squeezing the handle or turning a valve.

3. Operate cartridge-type extinguishers by turning them upside down and bumping the cylinder.

4. Water pump tanks operate by pumping the handle. Place foot on foot pump and direct the stream at the base of the fire.

B. Soda acid

1. Used for class A fires

2. Operate by turning the extinguisher upside-down.

3. Direct the stream at the base of the fire.

C. Carbon dioxide (CO_2)

1. Used for class B or C fires

2. Operate by pulling the pin and squeezing the lever.

3. Direct the discharge as close to the fire as possible, first at the edge of the flames, then gradually forward and upward.

D. Dry chemical

1. Used for class B or C fires

2. Operate by pulling the pin or rupturing the cartridge and squeezing the lever.

3. Direct at the base of the flames.

E. Foam

1. Use for Class A or B fires

2. Operate by turning the extinguisher upside-down.

3. Allow the foam to fall lightly on the fire.

FIRE SAFETY

Kind of Fire		Approved Type of Extinguisher						
		Mach up proper extinguisher with class of fire shown at left						
DECIDE THE CLASS OF FIRE YOU ARE FIGHTING... ↓	...THEN CHECK THE COLUMNS TO THE RIGHT OF THAT CLASS →	FOAM Solution of Aluminum Sulphate and Bicarbonate of Soda	CARBON DIOXIDE Carbon Dioxide Gas Under Pressure	SODA ACID Bicarbonate of Soda Solution and Sulphuric Acid	PUMP TANK Plain Water	GAS CARTRIDGE Water Expelled by Carbon Dioxide Gas	MULTI-PURPOSE DRY CHEMICAL	ORDINARY DRY CHEMICAL
A	CLASS A FIRES USE THESE EXTINGUISHERS → Ordinary Combustibles •Wood •Paper •Cloth etc.		X					X
B	CLASS B FIRES USE THESE EXTINGUISHERS → Flammable Liquids, Grease •Gasoline •Paints •Oils, etc.			X	X	X		
C	CLASS C FIRES USE THESE EXTINGUISHERS → Electrical Equipment •Motors •Switches etc.	X		X	X	X		

FIRE PREVENTION AND SAFETY

1. Locate all fire equipment, electrical control boxes, exits and first-aid equipment in the school shop.

Indicate how each class of fire is put out and which types of fire extinguishers can be used.

2. Class A

   Put out by:

   Fire extinguishers:

3. Class B

   Put out by:

   Fire extinguishers:

4. Class C

   Put out by:

   Fire extinguishers:

5. Class D

   Put out by:

   Fire extinguishers:

ANSWERS TO AS 2.1 (A4)

1. Evaluated by instructor

2. Put out by lowering its temperature or smothering
   Fire extinguishers: water, soda acid, dry chemical, foam

3. Put out by smothering it
   Fire extinguishers: carbon dioxide, dry chemicals, foam

4. Put out by using a non-conducting extinguishing agent (not water)
   Fire extinguishers: carbon dioxide, dry chemical

5. Put out by smothering with dry sand, dirt, salt or soda ash
   Fire extinguishers: none

MODULE: ORIENTATION TO MACHINE SHOP

UNIT II: SAFETY

LESSON 3: FIRST AID

I. Terms and definitions

A. Cardiopulmonary resuscitation (CPR)--restoration of breathing and heart function by means of external assistance, such as mouth-to-mouth breathing and external chest pressure

NOTE: Knowledge of CPR can be life-saving in an emergency. These simple techniques are best learned by seeing a demonstration done by a knowledgeable person.

B. First aid--immediate, temporary care given to an accident victim or person experiencing sudden illness until medical help arrives

C. Shock--a severe body reaction to bodily trauma or injury

D. Tetanus--an acute infectious disease caused by the toxin from bacteria which gain entry into the body through an area of injury (often minor). The disease affects the central nervous system.

II. General guidelines

A. Individual responsibilities

1. Reassure the injured person that everything possible is being done. Hearing the concerned voice of a co-worker is psychologically comforting to an injured person and can actually lessen the degree of shock.

2. Report <u>all</u> accidents and injuries to the instructor or job site supervisor--no matter how minor they may seem to be--as soon as possible.

3. Follow emergency procedures that have been adopted by the school, institution or company.

B. Instructor or supervisor duties

1. Always have a reason for any first aid performed.

2. Make accurate notes about the accident including the name of victim, time, place, cause or nature of the accident and any first aid that was administered.

3. Notifying the victim's family is the responsibility of the school, the job-site supervisor or the medical facility.

4. File a complete accident report and submit a copy to the proper persons on <u>the same day</u> as the accident.

III. Shock

A. Recognition

1. The skin is pale or bluish.

2. The skin may be moist and clammy, even cold to the touch.

3. The victim feels weak and may be confused or incoherent.

4. Pulse is rapid and weak; the breathing is shallow and the rate is fast and irregular.

5. Dull, lackluster eyes

6. Dilated pupils

B. Treatment

1. Do not delay immediate first aid treatment. It can be life saving.

2. Keep the victim lying down. Unless the victim has sustained a head or chest injury, elevate the feet slightly.

3. Without making the victim sweat, cover the victim to retain body heat.

4. Withhold liquids or food from the victim.

IV. First aid for injuries

A. Minor cuts

1. Clean with mild soap and water; rinse thoroughly with water; clean again as required.

2. Cover with a dry, sterile dressing.

3. Always consider tetanus as a potential hazard.

B. Puncture wounds, slivers and splinters

1. These through-the-skin wounds need prompt medical attention to avoid infection.

2. Do not attempt to remove deeply imbedded splinters, especially where the area appears infected.

3. Clean with soap and water; rinse thoroughly with water; clean again as required; cover with a dry, sterile dressing.

4. Always consider tetanus as a potential hazard.

C. Thermal (heat) burns

1. Give shock treatment to victim immediately.

2. Remove clothing from the area of burn, but do not remove material adhering to the burn area.

3. Apply a thick, dry, sterile dressing and bandage snugly to exclude air. If a sterile dressing is not available, use a close-woven, white, clean cloth.

D. Chemical burns

1. Immediately wash off chemicals with large quantities of running water and give shock treatment.

2. Cut off clothing from affected area.

3. Apply a thick, dry, sterile dressing and bandage snugly to exclude air. If a sterile dressing is not available, use a close-woven, white, clean cloth.

V. Eye Injury

A. Every eye injury should receive first aid attention.

B. Never permit the victim of an eye injury to rub the eye.

C. For an apparent minor object in the eye, have the person wink several times. If the tears produced by winking do not remove the object, assume that the object is embedded and use the following procedure.

1. Have the victim close his/her eyes.

2. Put a piece of moist, clean cotton over the closed lid.

CAUTION: Never use dry cotton near the eye as it will stick to the eyeball.

3. Place a bandage over both eyes to restrict eye movement, thus lessening eye injury.

4. Get the victim to a medical professional as soon as possible.

D. For chemical or acid splashes, flush the eyes immediately for at least five minutes at an eye-flushing station or use a bottled, portable flushing solution. Seek medical assistance without delay. Use water that is neither hot nor cold.

VI. Bleeding

A. Characteristics of types of bleeding

1. Arterial bleeding: bright-red blood spurts from the wound in sometimes alarming quantities

2. Venous bleeding: dark-red blood flows from the wound

3. Internal bleeding: blood may be coughed up, vomited or present in the victim's stools

B. Controlling bleeding

1. Use direct pressure at the bleeding site. Press firmly with fingers or palm of one hand.

2. If available, place a compress of sterile gauze or the next cleanest available material directly over the bleeding site.

3. Elevate the bleeding parts above heart level unless there is evidence of a fracture.

4. If blood soaks through the first compress, place another compress on it, but do not remove the first one.

5. Secure the compress with a pressure bandage.

6. Treat for shock.

C. Pressure points **(HO 3.1)**

CAUTION: The pressure point selected must be between the heart and the wound. Instruction by a qualified first aid instructor is the best way to learn where pressure points are and how to be sure the right one is selected.

1. Facial bleeding can often be controlled by pressing the facial artery.
2. Bleeding from the armpit, or sometimes the entire arm, can often be controlled by pressure on the subclavian artery.
3. Bleeding from an arm can often be controlled by pressure on the brachial artery.
4. Bleeding from a leg can often be controlled by firm pressure on the femoral artery.

VII. First aid for a victim of electrical shock **(HO 3.2)**

A. Safely remove the victim from the electrical source using the following procedures.

CAUTION: Do not touch the electrical circuit or the victim unless you are insulated or the power is off.

1. Turn off the electricity at a switch or circuit breaker or cut cables/wires by means of a wood-handled axe or insulated cutters, if available.
2. Use a dry stick, rope, leather belt, coat, blanket or any other nonconductor of electricity to separate the victim from the electrical circuit.

B. Call for assistance

1. Others in the area may be more knowledgeable than you about treating the victim.
2. Another person can call for professional medical help while first aid is being administered by a qualified person.

C. Check the victim's breathing and heartbeat. Mouth-to-mouth or cardiopulmonary resuscitation may be needed at this critical point.

CAUTION: Administer first aid only within your ability until medical help arrives.

D. Administer first aid for shock and burns as necessary.

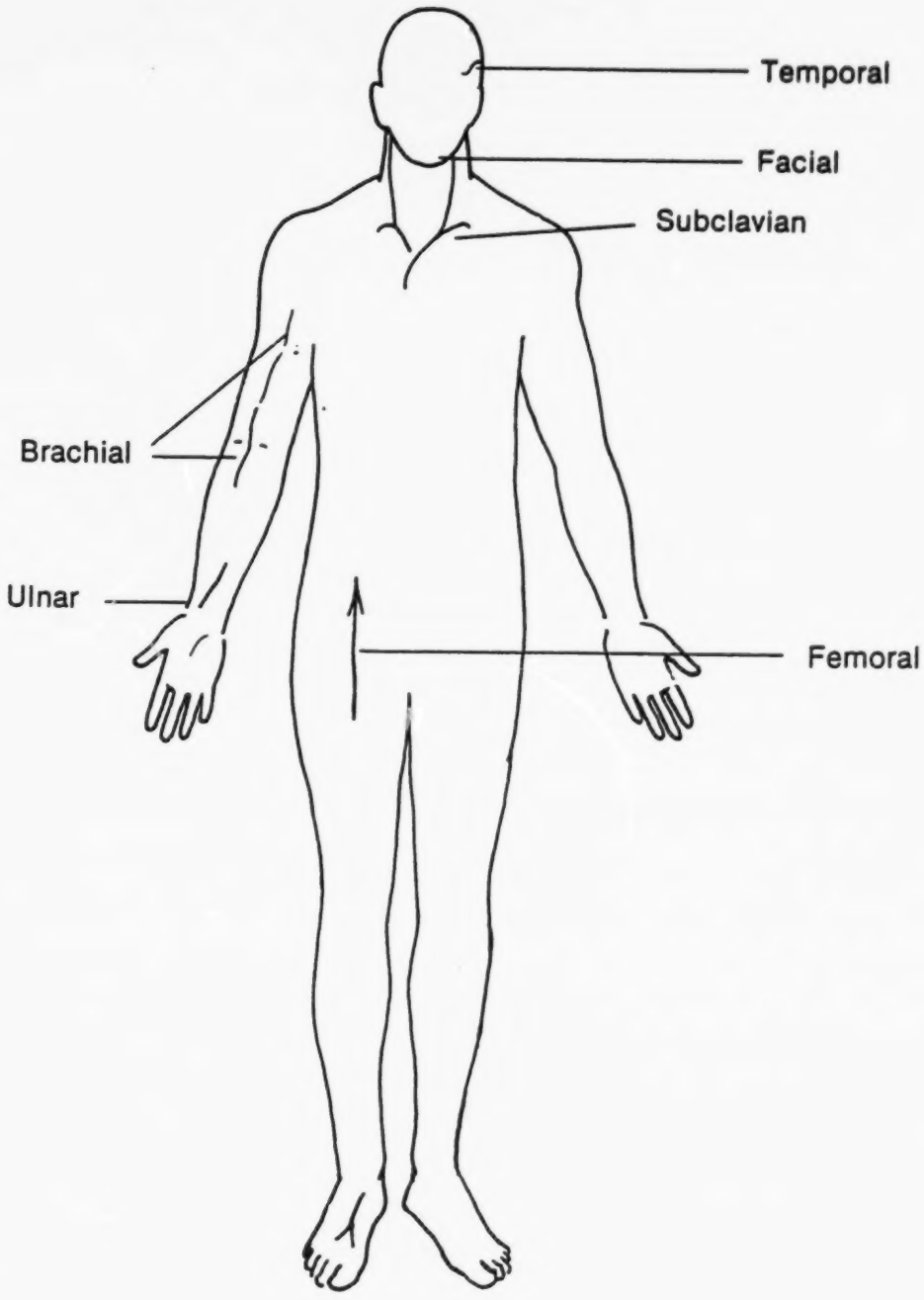
1. Use blankets or coats to help keep the victim warm and comfortable while waiting for help.
2. Raise the victim's legs slightly above head level to help prevent shock.
3. If the victim has suffered burns, bandage as follows.

   a. Cover your mouth and nostrils with gauze or a clean handkerchief to prevent germ transmission to the victim while treating the burns.

   b. Wrap burned area firmly with sterile gauze or clean linen or towels.

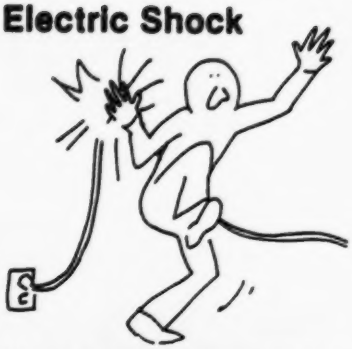
   CAUTION: Do not attempt any other treatment of burns without proper training.

PRESSURE POINTS



ELECTRICAL SHOCK AND FIRST AID

Electric Shock



It's the CURRENT (not the voltage) that does most damage. A high voltage causes violent muscular reaction-sometimes enough to throw victim clear of circuit.

Current Effects on the Body

- **Contraction of chest muscles** interferes with breathing. It can cause asphyxiation if prolonged.
- **Paralysis of nerve center** can result in respiratory failure.
- **Upset normal heart rhythm** can cause blood circulation to stop.
- **Hemorrhages and destruction** of tissues, nerves and muscles can result from heat of heavy current.

In an electrical emergency
Give First Aid

First...

If victim is in contact with live, INDOOR, low voltage electricity:

Shut off power if possible (pull plug, turn off switch).

Otherwise, FREE the VICTIM (use dry rope, stick,etc. Be sure your hands are dry and you're on a dry surface.)

If victim is in contact with live OUTDOOR wire:

Call power company -let THEM turn off power.

Then-as needed-treat victim for:

Burns

CUT away loose clothing.

COVER burned area with sterile dressing.

TREAT for shock and get medical aid at one.

Shock

TREAT causes of shock (stopped breathing, blood loss, etc.).

KEEP victim lying down. Place unconscious victim on side to allow drainage of fluids.

DON'T MOVE victim if you suspect neck or spine injury, unless absolutely necessary.

COVER only enough to maintain body heat.

GET medical help immediately.

FIRST AID

1. Describe the symptoms of shock.

2. Describe the first-aid treatment for shock.

3. Why is it always important to treat cuts, no matter how minor?

4. What is the first concern for a victim of chemical burns?

5. What is the first-aid treatment for bleeding?

Place an F before false statements and a T before true ones.

____ 6. Only major eye injuries should receive medical attention.

____ 7. A dry sterile dressing should be applied snugly to burns and medical attention sought.

____ 8. The first thing to do for a victim of electrical shock is to grab him or her away from the source of electricity.

____ 9. If blood soaks through the first compress on a bleeding wound, pull it off and apply another.

ANSWERS TO AS 3.1 (A1)

1. Pale or bluish, moist clammy, cold skin; victim feels week, confused or is incoherent; rapid pulse; shallow, fast, irregular breathing; dull, lackluster eyes; dilated pupils

2. Keep victim lying down; elevate feet slightly unless victim has sustained a head or chest injury, keep the victim covered; withhold liquids or food.

3. To prevent infection such as tetanus

4. To immediately wash off any chemicals on the skin with copious amounts of water and treat for shock

5. Apply pressure to lessen bleeding, place a compress over the bleeding site, treat for shock, elevate bleeding parts above heart level unless there is evidence of a fracture

6. F

7. T

8. F

9. F

MODULE: ORIENTATION TO MACHINE SHOP

UNIT II: SAFETY

UNIT TEST

Find the best definition for each of the terms listed on the right.

____ 1.	Federal agency which is concerned with providing safe, sanitary work conditions	a.	Compress
____ 2.	Acute, infectious disease caused by bacteria which enter the body through an injured area	b.	Accident
____ 3.	Unintentional event that results in injury or property damage	c.	First aid
____ 4.	Immediate, temporary care given an accident victim until medical help arrives	d.	Shock
____ 5.	State of being free from danger, risk or injury	e.	Cardiopulmonary resuscitation
____ 6.	Immediate care given to restore breathing and heart function	ab.	OSHA
____ 7.	Severe body reaction to injury or trauma	ac.	Safety
____ 8.	Dressing applied to a wound to help control bleeding	ad.	Tetanus

Select the answer which completes the statement or answers the question.

____ 9. When working around rotating machines, which is the best clothing choice?

a. Loose long-sleeved shirt, jeans and high-topped tennis shoes
b. Short-sleeved shirt or blouse with no neckwear or jewelry, cuffless pants and shoes which cover the entire foot
c. Dress shirt or blouse, jacket with tie and dress slacks or skirt
d. Fringed cowboy shirt, jeans and cowboy boots
e. Old, ragged clothing

____ 10. Which of the following is <u>not</u> part of the fire triangle?

a. Smoke
b. Heat
c. Oxygen
d. Fuel
e. All of the above

___ 11. Which type of fire extinguisher can be used on a class D fire?

a. Water
b. Foam
c. Carbon dioxide
d. Dry chemical
e. None of the above

___ 12. What class of fire occurs in electrical equipment?

a. A
b. B
c. C
d. D
e. E

___ 13. Guards and safety devices on equipment should be _____ .

a. Removed and disposed of when they are in the way
b. Bent out of the way
c. Painted safety green
d. Kept securely in place
e. Stored in readily available cabinets

___ 14. Who should defective hand tools and equipment be reported to immediately?

a. Friend
b. Instructor
c. Parents
d. Student health service
e. Classmates

___ 15. Which of the following symptoms would be typical of shock after an injury?

a. Dilated pupils; rapid, weak pulse
b. Hot, dry skin
c. Bright, glossy eyes
d. Slow pulse, hot feeling skin
e. Dilated pupils and slow pulse

___ 16. When should a complete accident report be submitted to the proper persons?

a. The same day as the accident
b. Soon after--usually the next day
c. During the same week
d. Before the end of the semester
e. When it's convenient

___ 17. A classmate has suffered a bad cut on the arm. The cut is cleaned and a dressing is applied but in a few minutes, the dressing is bloody and messy. Which is the best treatment?

a. Remove the blood-soaked compress and apply another.
b. Elevate the bleeding arm above heart level; apply pressure and an additional compress.
c. Apply a tourniquet and notify the instructor.
d. Treat for shock after removing and replacing compress.
e. None of the above

___ 18. A classmate has suffered an eye injury. Nothing appears to be embedded in the eye but the student complains of great pain. What should be done?

a. Use cold water to flush the eye.
b. Prevent the victim from rubbing the eye; get medical attention promptly.
c. Put a piece of dry cotton over the eye, bandage and get medical attention.
d. Flush with water, bandage with dry cotton and seek medical attention.
e. Use warm water to flush the eye.

___ 19. What is the proper order of treatment for a chemical burn?

a. Cut away clothing; give shock treatment; wash with running water.
b. Bandage and give shock treatment.
c. Immediately wash off chemical with large quantities of water; give shock treatment.
d. Bandage and seek immediate medical aid.
e. Give shock treatment and bandage.

___ 20. You see that a fellow worker has fallen onto a live electrical line. What is the first thing you should do?

a. Call for help immediately.
b. Check the victim's breathing and heartbeat.
c. Turn off electricity at the circuit breaker.
d. Treat for shock.
e. Pull them loose from the current.

___ 21. Which is <u>not</u> an electrical safety guideline?

a. Operate equipment within its rated capacity.
b. Handle electrical parts with a clean damp cloth.
c. Know where all emergency shut-down switches are located.
d. Tape worn or bare cables with electrically resistant tape.
e. Operate equipment only after receiving proper instructions.

___ 22. Which rule is <u>not</u> a good safety housekeeping rule?

a. Arrange machinery to permit safe, efficient work practices and ease in cleaning.
b. Keep floors clean and free from obstructions or slippery substances.
c. Keep sufficient housekeeping materials readily available.
d. Store materials, tools and supplies in their proper places.
e. Store oily rags in a well-ventilated, open can.

___ 23. When doing furnace work, what must be worn?

a. Safety glasses
b. Contact lenses
c. Welding goggles
d. A face shield
e. The proper shade of lens

___ 24. In the shop, when should eye protection be worn?

a. When the air is full of dust
b. Only when welding
c. For precision work
d. When there is a safety inspection
e. At all times

___ 25. What is meant if an equipment part is painted orange?

a. Dangerous part that could cut, crush, shock or injure
b. Part that could cause stumbling, snagging or falling
c. Part that is a fire hazard
d. Safe part of the machine
e. None of the above

___ 26. Which of the following is an OSHA employee expectation?

a. Report to OSHA within 48 hours any accident that is fatal.
b. Keep records of work-related injuries.
c. Follow all prescribed safety and health rules.
d. Display a poster explaining workers' rights and responsibilities.
e. All of the above

___ 27. Safety is the responsibility of _____ .

a. The company
b. The supervisor
c. The employee
d. All of the above
e. None of the above

___ 28. Which of the following does <u>not</u> promote safety in the shop?

a. Promptness
b. Cooperation
c. Reliability
d. Kidding around
e. Good personal hygiene

___ 29. What is the first step in safely lifting a 25-pound object?

a. Approach the load and estimate its weight and size.
b. Keep feet 4-6 inches apart.
c. Grab it and go.
d. Get a good hand hold on it before lifting.
e. Ask for assistance.

___ 30. When lifting an object, _____ .

a. Keep knees rigid
b. Keep one knee straight and one knee bent
c. Bend knees
d. Use just one hand
e. Keep feet touching

___ 31. It is <u>not</u> necessary to know _____ for good fire safety.

a. The location of the nearest fire department
b. Where the fire extinguishers are located and how to operate them
c. Where the fire exits are
d. The location of the nearest telephone
e. How to dispose of combustible materials

___ 32. Carbon dioxide fire extinguishers are used for which fires?

a. A and B
b. B and C
c. C and D
d. A only
e. A and C

___ 33. How are foam-type extinguishers operated?

a. Direct the foam to the base of the flames
b. Shake it
c. Turn the extinguisher upside-down
d. Puncture it
e. Any of the above

ANSWERS TO UNIT TEST

1.	ab	(A2)
2.	ad	(A1)
3.	b	(A2)
4.	c	(A1)
5.	ac	(A1)
6.	e	(A1)
7.	d	(A1)
8.	a	(A1)
9.	b	(A2)
10.	a	(A1)
11.	e	(A4)
12.	c	(A4)
13.	d	(A4)
14.	b	(A1)
15.	a	(A1)
16.	a	(A2)
17.	b	(A1)
18.	b	(A1)
19.	c	(A1)
20.	c	(A1)
21.	b	(A1)
22.	e	(A4)
23.	d	(A2)
24.	e	(A2)
25.	a	(A2)
26.	c	(A2)
27.	d	(A2)
28.	d	(A1)
29.	a	(A1)
30.	c	(A1)
31.	a	(A4)
32.	b	(A4)
33.	c	(A4)

NOTE: The number in parentheses after the answer indicates the competency that question evaluates.

MODULE: MACHINE SHOP ORIENTATION AND MATH
UNIT III: BASIC MATH SKILLS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to do calculations using whole numbers, fractions and decimals; identify mathematical terms; convert both within and between measuring systems; and use a simple calculator. This knowledge will be evidenced by specified scores on the pretest, assignment sheets and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match terms and definitions concerning decimals, tolerances and limits. (competency B1)

1.2 Determine and interpret decimal equivalents. (competency B5)

1.3 Perform arithmetic operations using decimals. (competencies B4 and B5)

1.4 Identify the tolerance and limits of a part specification.

2.1 Describe and make conversions within English and metric measuring systems. (competency B6)

2.2 Make conversions between measuring systems. (competency B3)

3.1 Match calculator terms and definitions.

3.2 Identify calculator keys and parts.

3.3 Perform mathematical calculations using the calculator. (competency B4)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Pretest
2. Answers to pretest
3. Lesson 1: DECIMALS AND TOLERANCES
   a. Information outline
   b. Handout
      HO 1.1: Decimal equivalents
   c. Assignment sheet
      AS 1.1: Decimals
   d. Answers to assignment sheet
4. Lesson 2: MEASUREMENT SYSTEMS AND CONVERSIONS
   a. Information outline
   b. Handout
      HO 2.1: English-metric conversion chart
   c. Assignment sheet
      AS 2.1: Measurement conversions
   d. Answers to assignment sheet
5. Lesson 3: USING A CALCULATOR
   a. Information outline
   b. Assignment sheet
      AS 3.1: Using the calculator
   c. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

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2. Boyce, John G., Samuel Slade and Louis Margolis. Mathematics for Technical and Vocational Schools. 6th ed. New York: Wiley and Sons, Inc., 1975.

3. Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., 1988.

4. McCarthy, Willard J., and Victor E. Repp. Machine Tool Technology. 4th ed. Bloomington, IL: McKnight Publishing Co., 1979.

B. Curriculum guide

1. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

C. Audiovisual

1. Machine Shop Math (videotext, Machine Trades series). Edina, MN: Video Training Resource, Inc., 1980.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Instead of information sheets covering basic addition, subtraction, multiplication, division and fractions, a pretest has been included before Lesson 1 to assist in determining which students need remedial math assistance. Students who complete the pretest to a specified level may progress to the assignment sheets. Those who do not pass should work through exercises in an approved math textbook.

2. When discussing the metric system, it is helpful for students to visualize the unit values. This can be accomplished by having metric measuring tools available for measurement of common objects.

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

PRETEST

Choose the letter which corresponds to the correct answer. If your instructor desires, show all calculations on on a separate piece of paper.

____ 1. What is the combined weight of four machines weighing 2,354 lbs., 1,952 lbs., 450 lbs. and 4,871 lbs.?

(a) 2,407 lbs. (b) 7,427 lbs. (c) 9,627 lbs. (d) 9,817 lbs. (e) 13,677 lbs.

____ 2. The following lengths of stock have been cut from a steel bar: 350 mm, 79 mm, 453 mm, 219 mm, 912 mm, 87 mm and 136 mm. How many millimeters (mm) have been cut off? (Figure without making allowance for what is wasted in cutting.)

(a) 2,236 mm (b) 2,239 mm (c) 3,410 mm (d) 3,671 mm (e) 3,730 mm

____ 3. Cut the following lengths of rod: 13 inches, 11 inches, 4 inches, 39 inches and 15 inches. How long a rod is needed (without allowance for wastage)?

(a) 62" (b) 73" (c) 82" (d) 109" (e) 118"

____ 4. Three shafts with a total length of 88 inches are cut from a 120-inch length of stock. How much is left?

(a) 31" (b) 32" (c) 42" (d) 51" (e) 308"

____ 5. Five pieces of steel bar measuring 35 mm, 102 mm, 180 mm, 621 mm and 63 mm are cut from a two-meter (2,000 mm) bar. Forty (40) mm is wasted in cutting. How many millimeters are left?

(a) 77 mm (b) 117 mm (c) 157 mm (d) 959 mm (e) 1,039 mm

____ 6. What length of bar is needed to make 19 four-inch long bolts? Allow a total of 5" for cut-off and chucking.

(a) 28" (b) 71" (c) 81" (d) 171" (e) 380"

____ 7. A screw has 38 threads per inch. What is the total number of threads in 6"?

(a) 44 (b) 182 (c) 222 (d) 228 (e) 456

____ 8. A total of 3,647 parts are produced per hour. How many parts are produced in seven hours?

(a) 3,654 (b) 3,696 (c) 21,287 (d) 24,922 (e) 25,529

___ 9. There are 950 liters of cutting fluid in each tank. How many liters are there in eight tanks?

(a) 119 L (b) 768 L (c) 7200 L (d) 7550 L (e) 7600 L

___ 10. Nine machines, each weighing 1,734 lbs., are to be shipped. What is the total weight to be shipped?

(a) 9,372 lbs. (b) 14,622 lbs. (c) 15,606 lbs (d) 16,618 lbs. (e) 16,640 lbs.

___ 11. Cut a 999 mm bar into 33 equal pieces. How long is each piece?

(a) 30.273 mm (b) 33.03 mm (c) 111 mm (d) 333 mm (e) 329,67 mm

___ 12. Jobs have been performed that took 55 minutes, 340 minutes, 231 minutes, 625 minutes and 189 minutes. How long, in hours and minutes, would it take to complete all of these jobs?

(a) 14 hours 40 minutes
(b) 24 hours
(c) 28 hours 8 minutes
(d) 32 hours 25 minutes
(e) 230 hours

___ 13. If 87 bolts were made from 19 feet of bar steel, how long is each bolt? (Allow a total of 1' for wastage.)

(a) 0.207 ft. (b) 0.23 ft. (c) 4.58 ft. (d) 9.3 ft. (e) 1,654 ft.

___ 14. How many 125 mm pieces can be cut from a two-meter (2000 mm) length of stock?

(a) 6 (b) 16 (c) 62 (d) 150 (e) 250,000

___ 15. If 187,432 pieces were made in eight hours, how many were made per hour?

(a) 11,056 (b) 20,730 (c) 22,154 (d) 23,429 (e) 1,499,456

In the answers to the following problems, reduce all resulting fractions to lowest terms.

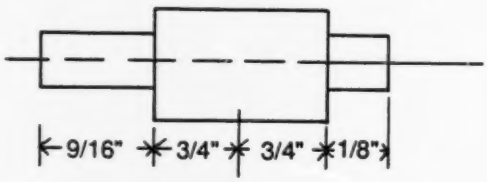
___ 16. 1/2 + 3/4 = _____

(a) 4/6 (b) 1 1/4 (c) 1 1/6 (d) 1 1/2 (e) 2/3

___ 17. 3/4 + 5/8 + 9/16 + 5/32 = _____

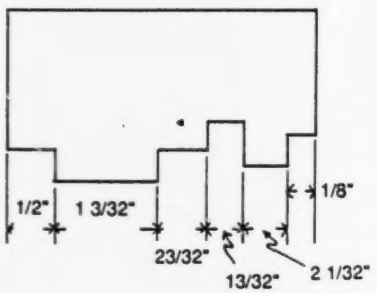
(a) 11/30 (b) 1 9/16 (c) 2 3/32 (d) 2 1/4 (e) 2 5/32

___ 18. What is the total length of this piece?



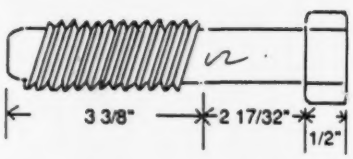
(a) 1/2" (b) 16/35" (c) 1 15/16" (d) 2 3/16" (e) 2 1/4"

___ 19. What is the total length of this profile gauge?



(a) 1 1/2" (b) 1 31/64" (c) 2 2/3" (d) 3 1/2" (e) 3 5/32"

___ 20. What is the length of this bolt?



(a) 5 1/2" (b) 5 21/32" (c) 6 13/32" (d) 6 1/2" (e) 6 3/4"

___ 21. 7/8 - 3/4 = _____

(a) 3/4 (b) 3/5 (c) 1/6 (d) 1/8 (e) 1

___ 22. 3/8 - 3/32 = _____

(a) 3/4 (b) 9/32 (c) 1/24 (d) 3/20 (e) 1/32

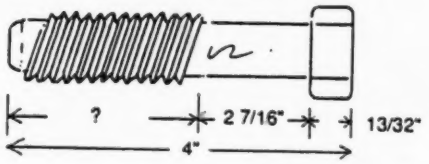
___ 23. 1 9/16 - 3/4 = _____

(a) 13/16 (b) 11/16 (c) 1 (d) 1 3/16 (e) 1 1/2

____ 24. Pieces measuring 5 3/32", 4 3/4" and 2 25/64" were cut from a steel bar that was 24 1/8" long. Allowing a total of 1/4" for waste, how much of the length of the bar is left?

(a) 12 15/64" (b) 12 1/32" (c) 12 57/64" (d) 11 57/64" (e) 11 41/64"

____ 25. What is the length of the threaded portion of this bolt?



(a) 1 7/12" (b) 1 5/32" (c) 1 3/8" (d) 2 1/16" (e) 1 11/32"

____ 26. 5/8 x 3/4 = _____

(a) 3/4 (b) 15/32 (c) 1/2 (d) 1/8 (e) 5/6

____ 27. 5 5/16 x 4 = _____

(a) 6 1/4 (b) 20 5/16 (c) 21 1/4 (d) 22 (e) 22 1/4

____ 28. 17/32 x 30/2 = _____

(a) 51/64 (b) 57/64 (c) 1/28 (d) 7 1/2 (e) 7 31/32

____ 29. What length of steel bar is needed to cut eight pieces that are each 9 7/8" long? Allow 3/32" of waste for each piece.

(a) 72 5/16" (b) 72 31/32" (c) 79 3/4" (d) 88 3/4" (e) 90"

____ 30. What length of hexagonal steel is needed to make nine chisels that are each 3 5/16" long? Allow 1/16" of waste per chisel.

(a) 27 5/15" (b) 28 25/32" (c) 29 15/16" (d) 30 3/8" (e) 32 5/16"

____ 31. 3/4 ÷ 3/8 = _____

(a) 2 (b) 1/2 (c) 3/16 (d) 1/8 (e) 9/32

____ 32. 2 1/2 ÷ 5 = _____

(a) 12 1/2 (b) 2 (c) 1/2 (d) 1/4 (e) 7 1/2

____ 33. 2 7/8 ÷ 3/8 = _____

(a) 1 5/64 (b) 6 1/4 (c) 7 2/3 (d) 8 7/8 (e) 9 1/8

___ 34. How many pieces 3 15/16" long can be cut from a bar 144" long?

(a) 35 (b) 36 (c) 38 (d) 41 (e) 45

___ 35. A screw has 55 threads and the threaded portion is 2 3/4" long. Determine the threads per inch.

(a) 10 (b) 15 (c) 20 (d) 30 (e) 151

Convert the following fractions to decimals.

___ 36. 5/8 = _____

(a) 0.4 (b) 0.725 (c) 0.625 (d) 0.525 (e) 1.3

___ 37. 1/8 = _____

(a) 0.1 (b) 0.125 (c) 0.12 (d) 0.225 (e) 1.1

___ 38. 11/16 = _____

(a) 0.75 (b) 0.7375 (c) 0.6775 (d) 0.6875 (e) 1.3

___ 39. 17/32 = _____

(a) 0.5312 (b) 0.5734 (c) 0.6512 (d) 1.5 (e) 5.734

___ 40. 57/64 = _____

(a) 0.0932 (b) 0.7214 (c) 0.8906 (d) 0.9231 (e) 1.7

Convert feet and inches to decimals.

___ 41. 9' 6 3/4" = _____

(a) 9.25' (b) 9.56' (c) 9.66' (d) 9.7' (e) 9.634'

___ 42. 3' 4 5/8" = _____

(a) 3.38' (b) 3.28' (c) 2.38' (d) 3.433' (e) 3.385'

___ 43. 14' 2 1/4" = _____

(a) 14.19' (b) 14.18' (c) 14.09 (d) 14.1' (e) 14.225'

Express each decimal as a fraction.

___ 44. 0.8 = _____

(a) 3/4 (b) 8/9 (c) 4/5 (d) 5/6 (e) 1/8

___ 45. 0.7 = _____

(a) 7/100 (b) 17/100 (c) 3/4 (d) 7/10 (e) 7/8

___ 46. 0.375 = _____

(a) 1/3 (b) 3/8 (c) 2/7 (d) 3 3/4 (e) 3/10

Convert decimals to feet and inches.

___ 47. 2.5000' = _____

(a) 2'8" (b) 2'7" (c) 2'6" (d) 2'5" (e) 250"

___ 48. 8.6333' = _____

(a) 8'6 1/3" (b) 8'6 3/5" (c) 8'7 3/5" (d) 8'7" (e) 8'7 1/3"

___ 49. 11.7396' = _____

(a) 11'7 9/10" (b) 11'8" (c) 11'8 7/10" (d) 11'8 9/10" (e) 11'8 7/8"

___ 50. 4.3854' = _____

(a) 43'3 9/10" (b) 4'3 8/10" (c) 4' 1/4" (d) 4' 4 5/8" (e) 4' 2/5"

NOTE: Completion of this pre-test to specified score is the student's partial evaluation for competency B1: Convert common fractions to decimal fractions and vise versa, and B5: Calculate amount of stock required.

ANSWERS TO PRETEST

1. c
2. a
3. c
4. b
5. d
6. c
7. d
8. e
9. e
10. c
11. a
12. b
13. a
14. b
15. d
16. b
17. c
18. d
19. d
20. c
21. d
22. b
23. a
24. e
25. b
26. b
27. c
28. e
29. c
30. d
31. a
32. c
33. c
34. b
35. c
36. c
37. b
38. d
39. a
40. c
41. b
42. e
43. a
44. c
45. d
46. b
47. c
48. c
49. e
50. d

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

LESSON 1: DECIMALS AND TOLERANCES

I. Terms and definitions

A. Decimal equivalent--a way to write fractions as decimals

Examples: 3/4 has a decimal equivalent of 0.75, and the decimal 0.3333 is approximately 1/3.

B. Decimal fraction--fractions in which the denominator is 10 or a multiple of 10

C. Decimal point--punctuation mark which separates whole numbers from decimals and defines the value of number positions to the right and left of the decimal point

D. Denominator--number on the bottom half of a fraction

E. Limits--the greatest and least dimensions on a print which are acceptable on the finished part

F. Numerator--number on the top half of a fraction

G. Tolerance--the value greater or less than a number on a print which is acceptable on a finished part

Example: ±.001 is a tolerance of one thousandth.

II. Reading and determining decimal equivalents

A. Determination

1. Calculated by dividing the numerator by the denominator

2. Can be derived by use of a decimal equivalent chart **(HO 2.1)**

B. Reading decimals

1. There are the same number of zeros in the denominator of a decimal fraction as there are figures to the right of the decimal point.

2. Examples: 0.1 is read as one-tenth (1/10)
0.02 is read as two hundredths (2/100)
0.003 is read as three thousandths (3/1000)
0.0004 is read as four ten-thousandths (4/10,000)
0.00005 is read as five hundred-thousandths (5/100,000)
0.000006 is read as six millionths (6/1,000,000)

C. To convert a decimal to a fraction, change it to a common fraction and reduce to its lowest terms or use a conversion table.

III. Operations using decimals

A. Addition and subtraction

1. The machinist works with blueprints, drawings and sketches and manipulates dials on machines which involve the addition and subtraction of decimal fractions.

2. Write numbers so that all decimal points are in a vertical column. Perform the operation, locating the decimal point in the same vertical column as the others.

B. Multiplication of decimals

1. Multiply the numbers just as for whole numbers.

2. Add the number of decimal places to the right of the decimal points in both of the numbers being multiplied. Starting at the extreme right of the answer, count to the left the total number of decimal places and place the decimal point.

C. Division of decimals

1. Move the decimal point in the divisor to the right until the divisor becomes a whole number. Move the decimal point in the dividend to the right the same number of places. (Add zeros if decimal places in the divisor exceed digits in the dividend.)

2. Locate the decimal point for the answer above the relocated decimal point. Divide to as many places as are required for the answer.

D. Rules for rounding off decimals

1. Check the drawing, sketch or specifications to determine the degree of precision required.

2. When doing calculations, consider the accuracy of each of the figures involved. The answer cannot be more accurate than the least accurate figure used in the calculations.

3. Locate the digit in the decimal place which indicates the required degree of precision.

4. Increase that digit by one if the digit which immediately follows is five or more, dropping all digits that follow.

5. Leave that digit as it is if the digit immediately following is less than five, dropping all digits that follow.

Example: The total of a column of figures is 0.63865. Round off the figure to three places (thousandths). The 6 in the fourth place is greater than five, therefore the third digit is increased by one. The answer stated in three decimal places is: 0.639

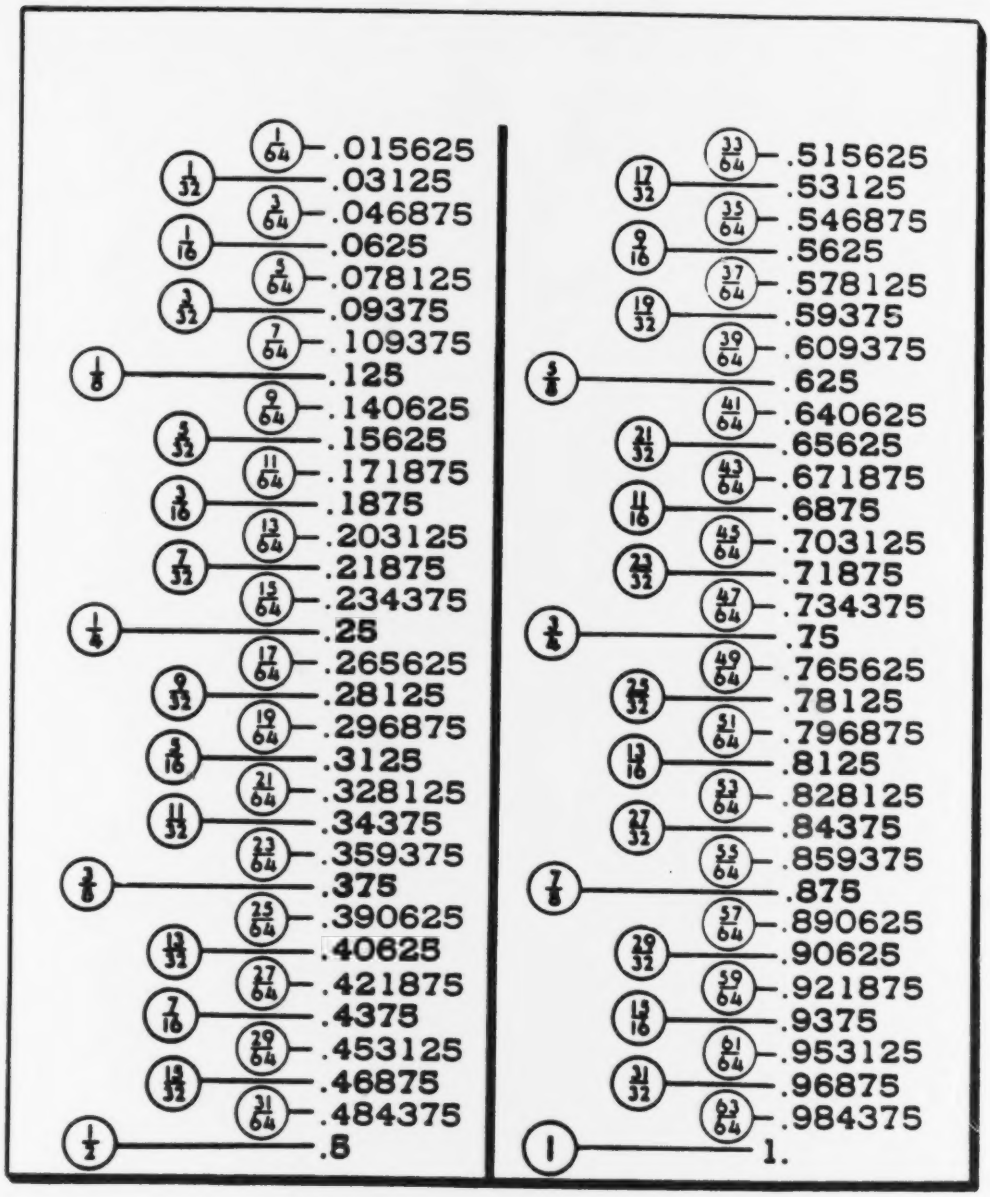
IV. Tolerance

A. Tolerance is the amount of variation permitted in a part's size.

Example: A shaft is specified as 1 ±0.0005 inches. This means that the measurement of the shaft cannot exceed 1.0005 inches or be less than 0.9995 inches. It has a tolerance of .0005. Calculations involving this part must be carried to the fourth decimal place to assure accuracy.

B. Limits in the above example are 1.0005 and 0.9995.

DECIMAL EQUIVALENTS



INCHES-TO-DECIMAL CONVERSION (PART OF A FOOT)

Fractions of Inches		Inches	
1/16"	.0052	1"	.0833
3/32"	.0078	2"	.1667
1/8"	.0104	3"	.2500
5/32"	.0130	4"	.3333
3/16"	.0156	5"	.4167
7/32"	.0182	6"	.5000
1/4"	.0208	7"	.5833
9/32"	.0234	8"	.6667
5/16"	.0260	9"	.7500
3/8"	.0313	10"	.8333
7/16"	.0364	11"	.9167
1/2"	.0417	12"	1.0000
9/16"	.0468		
5/8"	.0521		
11/16"	.0572		
3/4"	.0625		
13/16"	.0677		
7/8"	.0729		
15/16"	.0781		

(Note: Do not confuse inches to decimal with decimal equivalents.)

DECIMALS

Using the chart in HO 1.1, convert the following into decimal equivalents.

1. 1/16 = _____
2. 7/8 = _____
3. 1/2 = _____
4. 1/64 = _____

Using the chart in HO 1.1, convert the following decimal equivalents into fractions.

5. 0.4375 = _____
6. 0.3125 = _____
7. 0.125 = _____
8. 0.6875 = _____

Convert the following feet and inches to decimals, rounding off to the fourth decimal place.

9. 9' 6 3/4" = _____
10. 3' 4 5/8" = _____
11. 14' 2 1/4" = _____
12. 1' 6" = _____

Solve the following decimal problems, rounding off to the fourth decimal place.

13. 0.046 + 0.00002 + 0.653 + 8.1673 = _____
14. 0.5 + 0.015 + 0.171 + 8.7003 + 16.37 = _____
15. 8.763 - 1.04 = _____
16. 126.373 - 126.29 = _____
17. 0.9321 x 1.76 = _____
18. 9.429 x 8.670 = _____
19. 0.0672 ÷ 28.5 = _____
20. 73.16 ÷ 24.38 = _____

What are the limits of these tolerances?

21. 2.00 ±.002
22. 3.50 ±.0032

23. 0.679 ±.001

24. What is the total length of three shafts with the following lengths: 3.165", 8.430" and 2.61"?

25. A machinist milled 0.037" from a 3" thick steel block. What is the thickness of the block when finished?

26. What length of stock is needed to make five 2.125-inch pins (not considering wastage)?

27. How high is a stack of 13 washers if each washer is 0.325" thick?

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B1: Convert common fraction to decimal fraction and vise versa, and competency B5: Calculate amount of stock required.

ANSWERS TO AS 1.1

1. 0.0625
2. 0.875
3. 0.5
4. 0.015625
5. 7/16
6. 5/16
7. 1/8
8. 11/16
9. 9.5625'
10. 3.3854'
11. 14.1875'
12. 1.5'
13. 8.8663
14. 25.7563
15. 7.723
16. 0.083
17. 1.6405
18. 81.7494
19. 0.0024
20. 3.0008
21. 1.998 to 2.002
22. 3.497 to 3.503
23. 0.678 to 0.680
24. 14.205"
25. 2.963"
26. 10.625"
27. 4.225"

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

LESSON 2: MEASUREMENT SYSTEMS AND CONVERSIONS

I. Systems used for measurement

A. The traditional system is the English or U.S. customary system.

1. In order to convert within the system, one must know the relationships between measurements, such as the number of inches per foot and the number of quarts per gallon.

2. English equivalents

<u>Length and area</u>		
1 foot (ft.) (')	=	12 inches (in.) (")
1 yard (yd.)	=	3 feet (ft.) (')
1 mile (mi.)	=	5,280 feet (ft.)
1 square foot	=	144 square inches (sq. in.)
1 acre	=	43,560 square feet (sq. ft.)
<u>Volume measures for fluids</u>		
1 quart (qt.)	=	2 pints (pt.) or 4 cups
1 gallon (gal.)	=	4 quarts (qt.) or 231 cubic inches (cu. in.)
<u>Weight</u>		
1 pound (lb.)	=	16 ounces (oz.)
1 ton	=	2000 pounds in the U.S. (short ton)

3. The basic units of length used by machinists are the inch and fractions of an inch, such as halves, quarters, eighths, sixteenths, thirty-seconds and sixty-fourths.

a. Machinists also use inches expressed as decimals, such as thousandths and ten-thousandths of an inch.

b. In the manufacture of precision measuring tools, it is often necessary to work in millionths of an inch.

3. The basic units of volume used are quarts and gallons.

4. The basic unit of weight or mass is the pound.

B. The metric system is used by scientists everywhere and in most countries of the world.

1. In U.S. manufacturing, measurements are gradually being changed over to metric, which may take a number of years. Many companies have already converted to the metric system.

2. Because it is based on tens, conversion within this measuring system is easier than within the English system.

3. The basic units of length used are the meter (m), centimeter (cm) and millimeter (mm).

4. The basic unit of volume is the liter (l). (one liter = one cubic decimeter)

5. The basic units of weight or mass are the gram (g) and kilogram (kg).

6. Multiples or parts of the basic unit are expressed by adding a prefix.

   a. The prefix "kilo-" means 1000, so 1 kilometer = 1000 meters.

   b. The prefix "deci-" means 1/10, so 1 decimeter = 0.1 meter.

   c. The prefix "centi-" means 1/100--1 centimeter = 0.01 meter.

   d. The prefix "milli-" means 1/1000--1 millimeter = 0.001 meter.

II. Conversions between English and metric measures **(HO 2.1)**

A. Generally, when working with English units, think in terms of English units. When working in metric units, think in terms of metric units and only convert when necessary.

B. Common conversions

1. One inch equals 25.4 mm (millimeters) or 2.54 cm (centimeters).

   a. To convert inches to millimeters, multiply by 25.4.

   b. To convert millimeters to inches, divide by 25.4.

   c. Other conversions are made in the same way.

2. One meter equals 39.37 inches or slightly more than a yard.

3. One square inch (in^2) equals 6.4516 square centimeters (cm^2) or 645.16 square millimeters (mm^2).

4. One cubic inch (in^3) equals 16.387064 cm^3 or 16387.064 mm^3.

5. One gallon equals 3.785 l (liters).

6. One kilogram (kg) equals 2.205 pounds.

ENGLISH-METRIC CONVERSION CHART

Measures of Length

1 millimeter (mm) = 0.03937 inch
1 centimeter (cm) = 0.39370 inch
1 meter (m) = 39.37008 inches
= 3.2808 feet
= 1.0936 yards
1 kilometer (km) = 0.5214 mile
1 inch = 25.4 millimeters (mm)
= 2.54 centimeters (cm)
1 foot = 304.8 millimeters (mm)
= 0.3048 meter (m)
1 yard = 0.9144 meter (m)
1 mile = 1.609 kilometers (km)

Measures of Area

1 square millimeter = 0.00155 square inch
1 square centimeter = 0.155 square inch
1 square meter = 10.764 square feet
= 1.196 square yards
1 square kilometer = 0.3861 square mile
1 square inch = 645.2 square millimeters
= 6.452 square centimeters
1 square foot = 929 square centimeters
= 0.0929 square meter
1 square yard = 0.836 square meter
1 square mile = 2.5899 square kilometers

Measures of Capacity (Dry)

1 cubic centimeter (cm^3) = 0.061 cubic inch
1 liter = 0.0353 cubic foot
= 61.023 cubic inches
1 cubic meter (m^3) = 35.315 cubic feet
= 1.308 cubic yards
1 cubic inch = 16.38706 cubic centimeters (cm^3)
1 cubic foot = 0.02832 cubic meter (m^3)
= 28.317 liters
1 cubic yard = 0.7646 cubic meter (m^3)

Measures of Capacity (Liquid)

1 liter = 1.0567 U.S. quarts
= 0.2642 U.S. gallon
= 0.2200 Imperial gallon
1 cubic meter (m^3) = 264.2 U.S. gallons
= 219.969 Imperial gallons
1 U.S. quart = 0.946 liter
1 Imperial quart = 1.136 liters
1 U.S. gallon = 3.785 liters
1 Imperial gallon = 4.546 liters

Measures of Weight

1 gram (g) = 15.432 grains
= 0.03215 ounce troy
= 0.03527 ounce avoirdupois
1 kilogram (kg) = 35.274 ounces avoirdupois
= 2.2046 pounds
1000 kilograms (kg) = 1 metric ton (t)
= 1.1023 tons of 2000 pounds
= 0.9842 ton of 2240 pounds
1 ounce avoirdupois = 28.35 grams (g)
1 ounce troy = 31.103 grams (g)
1 pound = 453.6 grams
= 0.4536 kilogram (kg)
1 ton of 2240 pounds = 1016 kilograms (kg)
= 1.016 metric tons
1 grain = 0.0648 gram (g)
1 metric ton = 0.9842 ton of 2240 pounds
= 2204.6 pounds

MEASUREMENT CONVERSIONS

1. Express 3 feet 5 3/8 inches as inches.
2. Express each of the following as feet and inches. Express inches to the nearest 64th.
   a. 6.9 feet
   b. 8.7 feet
   c. 2.13 feet
3. How many pints are there in seven gallons?
4. How many millimeters are there in a decimeter?
5. How many centimeters are there in a meter?
6. How many millimeters are there in a meter?
7. How many millimeters are there in a centimeter?
8. How many millimeters are 66.6 centimeters?
9. How many millimeters are 1.05789 meters?
10. Four pieces measuring 1.23 m, 10.4 cm, 369 mm and 278 mm are cut from a steel bar that is two meters in length. Allowing 4.5 mm for waste, how much is left?
11. Convert 1.56 meters to inches (to the nearest 1/64th inch).
12. Convert 63.2 cm to inches (to the nearest 1/64th inch).
13. Convert 56 inches to millimeters.
14. Convert 3.5 feet to centimeters.
15. Convert five millimeters to inches (to the nearest 1/64th inch).
16. A steel bar is 16' long. Convert this length to meters (round off to thousandths place).

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B3: Convert customary measurements to metric and vice versa.

ANSWERS TO AS 2.1

1. 41 3/8"
2. a. 6' 10 51/64"
   b. 8' 8 13/32"
   c. 2' 1 9/16"
3. 56
4. 100 mm
5. 100 cm
6. 1000 mm
7. 10 mm
8. 666 mm
9. 1057.89 mm
10. 14.5 mm
11. 61 27/64"
12. 24 7/8"
13. 1422.4 mm
14. 106.75 cm
15. 13/64"
16. 4.877 meters

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

LESSON 3: USING A CALCULATOR

NOTE: The following information generally applies to simple calculators. However, the features, location of keys and methods of operation can vary from manufacturer to manufacturer and from model to model. Refer to the owner's manual for specific instructions.

I. Terms and definitions

A. Calculator--mechanical or electronic device used for performing mathematical calculations

B. Constant--quantity or factor that does not vary throughout a mathematical operation

C. Exponent--small figures above and to the right of a number or symbol which indicate how many times the number or symbol is to be multiplied by itself

D. Exponentiation--multiplication operation involving exponents

E. Memory--a number location which is not affected by operations in the primary register; holds the same number until replaced or cleared

F. Reciprocal--quantity resulting from the division of one (1) by the given quantity

Example: 1/8 is the reciprocal of 8.

G. Variable--function or term which has no fixed value (opposite of constant)

II. Calculator keys and parts

A. Display

B. Power or off/on key

C. Plus/minus key--changes the sign of figure being displayed

D. Square root function key

E. Percent key

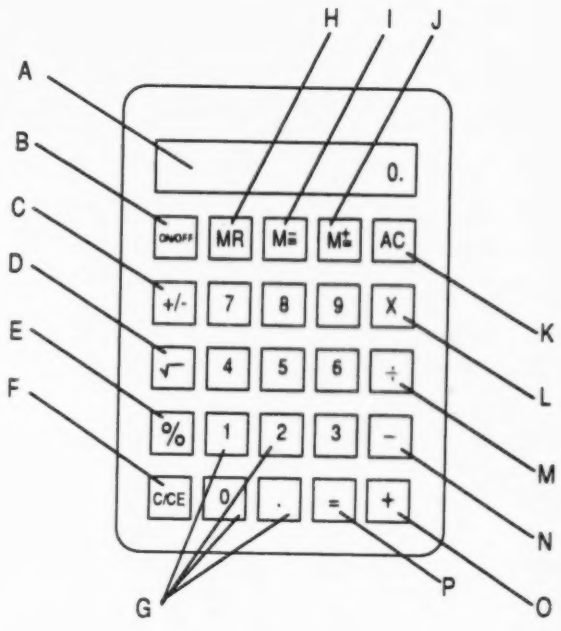
F. Clear entry key--erases the last entry

G. Numeral and decimal point keys

H. Memory recall key--displays the value stored in the memory

I. Memory subtract key--subtracts the last value entered from the value stored in the memory

J. Memory add key--adds the last value entered to the value stored in the memory



K. All clear key (reset key)--clears all registers and memories

L. Multiplication function key

M. Division function key

N. Subtraction function key

O. Addition function key

P. Equals key--completes an operation

III. Calculation

A. Basic operations

1. Addition, subtraction and multiplication are performed by entering the first number; pressing the appropriate function key; entering the number to be added, subtracted or multiplied; then pressing the equal key.

2. Division is performed by first entering the dividend, pressing the division function key, then entering the divisor and pressing the equal key.

3. Between calculations, press the key which clears all of the registers and memories.

4. If a mistake is made while entering a number, use the clear entry key to clear the last number entered, then enter the correct number.

5. If the answer to a problem exceeds the capacity of the calculator, the answer will appear with an E beside it. The answer is an approximate one which must be multiplied by a power of ten to get the full approximate answer.

B. Mixed calculations

1. Performed by pressing the appropriate operation after each entry

Example: (35 + 28 - 15) x 7 ÷ 3 = ? Solution: Enter 35 and press the addition key; enter 28 and press the subtraction key, enter 15 and press the multiplication key; enter 7 and press the division key; enter 3 and press the equal key. The display will show the answer, 112.

2. Priority of operations

NOTE: It is important to group operations correctly and put them in the correct order. If operations are not performed in the correct order, an incorrect answer could result.

a. Perform operations within parentheses first.

b. Perform any exponentiations.

c. Multiply and/or divide from left to right.

d. Perform additions and/or subtractions from left to right.

C. Percent calculations

1. The percentage of a given number is calculated by entering the number, pressing the multiplication key, entering the percentage number and pressing the percent key.

   Example: Find 33% of 544. Solution: Enter 544, press the multiply key, enter 33 and press the percent key. The answer appearing in the display is 179.52.

2. Add on percentage--For problems in which a certain percentage is added (such as when determining the total price including tax), enter the number; press the multiply key, enter the percentage; press the percent key and then the addition key; and then press the equal key.

   Example: An item is marked $8.67. What is the total price including the 6.5% sales tax? Solution: Enter 8.67 and press the multiply key; enter 6.5 and press the percent key; then press the addition key and the equal key. The answer will appear as 9.23355 or $9.23 rounded off to hundredths.

3. Discounts--Follow the same steps as for add-ons, except press the subtraction key instead of the addition key.

   Example: The amount due for payment is discounted by 15% if paid within 30 days. If the bill is for $112.56 and the payment is made on time, how much should be paid? Solution: Enter 112.56 and press the multiply key; enter 15 and press the percent key; then press the subtraction key and the equal key. The answer will appear as 95.676 ($95.68).

D. Constants

1. When performing repeated operations using the same multiplier or divisor, entering the multiplier each time is unnecessary.

2. To multiply constants, enter the constant first and press the multiplication key; enter the variable and then the equal key.

   a. For subsequent variables, enter the variable number only and then the equal key.

   b. One can continue to do these repeated calculations until another variable is entered or the calculator is cleared or turned off. (Be careful not to hit any other keys.)

   Example: An employee earns $12 per hour. How much will be paid for 40 hours? 80 hours? 160 hours? Solution: Enter the constant (12) and press the multiplication key. Then enter the first variable (40) and press the equal key. The answer is $480. For the next variable, enter 80 and press the equal key. The answer is $960. Repeat for the next variable (answer: $1,920).

3. In division, the divisor can be a constant. Enter the variable first and then press the division key; enter the divisor constant and press the equal key. In subsequent calculations using this constant, enter the dividend (variable) and press the equal key.

E. To calculate the reciprocal of a number, enter the number and press the division and equal keys.

F. To calculate the square root of a number, enter the number and press the square root key.

G. To square, cube or raise a number to a certain power, enter the number, press the multiply key and press the equal key n-1 times, (n = power).

Example: What is 6^7? Solution: Enter 6; press the multiplication key and then press the equal key 6 (7-1) times. The answer is 279,936.

H. Memory

1. Memory keys are used in mixed operations.

2. Use of the memory keys allows storage of intermediate answers in a special register while other operations are performed, then recall of the stored number, rather than reentering it.

   Example: $\sqrt{23^2 - 16^2 + 4.2^2} = ?$ Solution: After squaring the numbers, the resulting numbers can be added and subtracted from the memory register. Then recall the number in the register to determine the square root. The answer is 17.05 (rounded off to hundredths).

   Steps:

   a. Enter 23; then press the multiplication and the equal keys; press the M+ key to enter the result into the memory register.

   b. Enter 16 and square it as in step a. Press the M- key, which subtracts the result from what is already in the memory register and stores the result.

   c. Enter 4.2; square it and press the M+ key to add the result to what is in the memory register.

   d. Recall the contents of the memory register by pressing the MR key, then find the square root by pressing the square root key.

USING THE CALCULATOR

Use a calculator to solve the following problems.

1. 5.772 + 456.96 = _____
2. 1,945,211 + 2,347,111 = _____
3. 7,954,298 - 5,383,199 = _____
4. 542.13 - 834 = _____
5. 111 + 55 - 34 + 206.3 + 367 = _____
6. 98.2 - 43 - 22.54 + 322 - 53.67 = _____
7. 0.822 x 6,245 = _____
8. 45,899 ÷ 23.67 = _____
9. (67.5 + 22.8) ÷ 3 - 5 = _____

Use the constant function to convert each of the following into centimeters. (Round off to thousandths.)

10. 56.23 inches
11. 2.4571 inches
12. 9.324 inches
13. 10.5 inches

Calculate the square root of the following numbers. (Round off to ten-thousandths.)

14. 544
15. 4.6911
16. 7.0001

Find the decimal equivalent of the following numbers.

17. 1/64
18. 1/32
19. 3/16
20. 11/32

Use the percent key to solve the following problems.

21. $241.56 + 5.5% tax = _____
22. $95.45 - 30% discount + 6.5% tax = _____

23. ($4.50 + $0.30 + $0.99 + $2.99) - 25% discount + 5.25% tax = _____

Use the memory keys to solve the following problems.

24. 36 inches - 3/4 inch - 3/64 inch - 7/32 inch - 5/16 inch = _____

25. 11.52 ÷ 5.77 - 3/4 = _____

26. $\sqrt{\text{ of } 33^2 + 24^2}$ = _____

27. $$\frac{4\,[2\,(8.5 - 3.25) + (1.25 + 1.1)]}{[8\,(7.3 - 6.2) + 3]}$$

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B4: Use calculator to perform mathematical operations.

ANSWERS TO AS 3.1

1. 462.732
2. 4,292,322
3. 2,571,099
4. -291.87
5. 705.3
6. 300.99
7. 5133.39
8. 1939.1212
9. 25.1
10. 142.824 cm
11. 6.241 cm
12. 23.683 cm
13. 26.67 cm
14. 23.3238
15. 2.1659
16. 2.6458
17. 0.015625
18. 0.03125
19. 0.1875
20. 0.34375
21. $254.85
22. $71.16
23. $6.93
24. 34.6719"
25. 1.2465
26. 40.8044
27. 4.3559

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT III: BASIC MATH SKILLS

UNIT TEST

Match terms on the right with definitions.

____	1.	Denominator is 10	a. Constant
____	2.	Function or term which has no fixed value	b. Decimal fraction
____	3.	Number on the bottom of a fraction	c. Denominator
____	4.	Number on the top of a fraction	d. Exponent
____	5.	Greatest and least dimensions which are acceptable on a finished part	e. Limits
____	6.	Quantity resulting from the division of one by a number	ab. Numerator
____	7.	Factor that does not vary throughout a mathematical calculation	ac. Reciprocal
			ad. Variable

Using unit handouts where helpful, choose the best answer to each question.

____ 8. Three pieces measuring 5 1/2 inches, 3 7/8 inches and 2 5/64 inches are cut from a 30-inch cast-iron bar. Allowing 1/8 inch for each cut, how much stock is left?

a. 10 3/64 in.
b. 11 3/8 in.
c. 17 63/64 in.
d. 18 11/64 in.
e. 19 13/49 in.

____ 9. What is the decimal equivalent to the answer to question #8?

a. 0.453 in.
b. 10.05 in.
c. 17.98 in.
d. 18.17 in.
e. 19.26 in.

____ 10. What is the length of stock needed to cut five 3.692" rods? (Allow 1/8" for each cut.)

a. 8.7 in.
b. 13.69 in.
c. 15.7 in.
d. 18.96 in.
e. 31.8 in.

____ 11. Express the answer to question #10 to the nearest 64th inch.

a. 82/64 in.
b. 8 7/64 in.
c. 114/64 in.
d. 15 7/64 in.
e. 18 61/64 in.

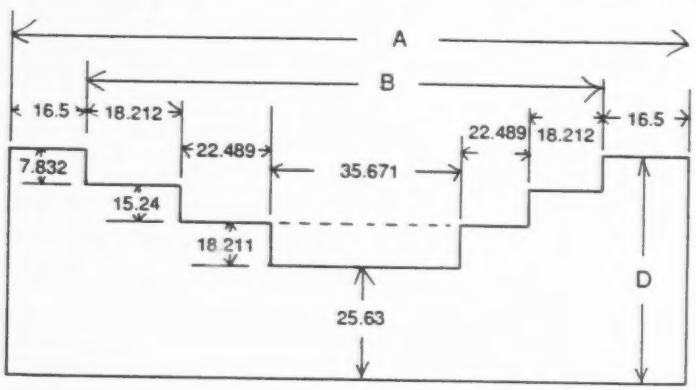
___ 12. How is the number 0.00015 read?

a. 15 ten-thousandths
b. 15 hundred-thousandths
c. 1.5 hundred-thousandths
d. 1.5 thousandths
e. 15 thousandths

___ 13. What is the decimal equivalent of 6'6 3/4"?

a. 0.675 feet
b. 6.56 feet
c. 6.63 feet
d. 6.67 feet
e. 6.675 inches

Use the drawing of the template below for questions 14-19. Dimensions are given in millimeters.



___ 14. What is dimension A in millimeters?

a. 92.87 mm
b. 117.403 mm
c. 150.073 mm
d. 185.75 mm
e. 195.75 mm

___ 15. What is dimension B in millimeters?

a. 99.3 mm
b. 114.68 mm
c. 117.073 mm
d. 133.57 mm
e. 152.75 mm

___ 16. What is dimension D in millimeters?

a. 30.13 mm
b. 66.913 mm
c. 67.42 mm
d. 82.83 mm
e. 102.52 mm

___ 17. How many templates can be cut from steel stock 70 mm wide and 500 mm long?

a. None
b. 1
c. 2
d. 3
e. 4

___ 18. Convert dimension D to inches.

a. 1.1 in.
b. 2.634 in.
c. 3.282 in.
d. 26.5 in.
e. 32.8 in.

___ 19. Convert dimension D to feet.

a. 0.2195'
b. 0.2634'
c. 0.2735'
d. 0.3282'
e. 13.25'

___ 20. What length of stock is needed to make 25 pins that are 75 mm long? (Allow 2.4 mm wastage per pin.)

a. 63 mm
b. 78.125 mm
c. 1,815 mm
d. 1,935 mm
e. 2,475 mm

___ 21. One-inch diameter rolled steel weighs 2.68 pounds per foot of length. How many feet are there in a bundle weighing 189.65 pounds?

a. 63.3'
b. 70.765'
c. 508.262'
d. 707.64'
e. 50,826.2'

___ 22. The width of a part is specified as 2.67 +.001 mm. To be within tolerance, the finished piece after milling can have a width of _____ .

a. 2.66 mm
b. 2.671 mm
c. 2.673 mm
d. 2.681 mm
e. 2.27 mm

___ 23. A centimeter is _____ .

a. 1/10 of a meter
b. 1/100 of a meter
c. 10 millimeters
d. 100 decimeters
e. 100 millimeters

___ 24. A decimeter is _____ .

a. 1/10 of a meter
b. 1/100 of a meter
c. 10 millimeters
d. 10 meters
e. 100 meters

___ 25. Convert 6.6 inches to millimeters.

a. 0.264 mm
b. 2.598 mm
c. 16.5 mm
d. 167.64 mm
e. 198 mm

Use a calculator to find the answers to the following problems.

___ 26. 9 + 3 x 5 x (49.21 - 11.3) ÷ 3 = _____ .

a. 123.183
b. 198.55
c. 243.75
d. 758.2
e. 980.433

___ 27. Square root of 8.784 = _____ .

a. 1.722
b. 2.964
c. 9.349
d. 77.159
e. 677.762

___ 28. Decimal equivalent of 12/51 = _____ .

a. 0.2351
b. 0.2353
c. 2.353
d. 4.25
e. 12.51

___ 29. 45 in. - 3/64 in. - 9/32 in. - 1/16 in. = _____ .

a. 4.2 in.
b. 44.5 in.
c. 44.609 in.
d. 45.391 in.
e. 46.375 in.

___ 30. 67 + (square root of 15.34) = _____ .

a. 3.917
b. 8.19
c. 9.074
d. 70.917
e. 82.34

ANSWERS TO UNIT TEST

1.	b	(B1)	16.	b	(B6)
2.	ad	(B4)	17.	d	(B5)
3.	c	(B1)	18.	b	(B3)
4.	ab	(B1)	19.	a	(B3)
5.	e	(B6)	20.	d	(B5)
6.	ac	(B4)	21.	b	(B5)
7.	a	(B4)	22.	b	(B6)
8.	d	(B5)	23.	b	(B3)
9.	d	(B1)	24.	a	(B3)
10.	d	(B5)	25.	d	(B3)
11.	e	(B1)	26.	b	(B4)
12.	b	(B1)	27.	b	(B4)
13.	b	(B1)	28.	b	(B4)
14.	c	(B6)	29.	c	(B4)
15.	c	(B6)	30.	d	(B4)

MODULE: MACHINE SHOP ORIENTATION AND MATH
UNIT IV: GEOMETRIC FIGURES AND FORMS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to define, use and apply geometric concepts, formulas, theorems and relationships. This knowledge will be evidenced by achieving a specified score on the assignment sheets and the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match geometric terms with definitions.

1.2 Identify angle measurements.

1.3 Identify angle types.

1.4 Identify and use angle relationship theorems.

2.1 Match terms and definitions concerning figures and geometric relationships.

2.2 Identify and use triangle definitions, formulas and theorems.

2.3 Identify and use quadrilateral definitions, formulas and theorems.

2.4 Identify and use circle definitions, formulas and theorems.

2.5 Determine the volume of rectangular solids.

2.6 Determine the outside area and volume of cylinders.

2.7 Determine the volume of spheres.

2.8 Identify and use polygon definitions and formulas.

2.9 Construct simple geometric forms. (competency B13)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT IV: GEOMETRIC FIGURES AND FORMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: ANGLES

   a. Information outline

   b. Assignment sheet

      AS 1.1: Angles

   c. Answers to assignment sheet

2. Lesson 2: POLYGONS, CIRCLES AND SOLIDS

   a. Information outline

   b. Handouts

      HO 2.1: Chord constants
      HO 2.2: Distance constants for locating holes on a circle

   c. Assignment sheets

      AS 2.1: Calculating amount of stock required
      AS 2.2: Calculating feature dimensions and areas
      AS 2.3: Geometric applications

   d. Answers to assignment sheets

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Boyce, John G., Samuel Slade and Louis Margolis. Mathematics for Technical and Vocational Schools. 6th ed. New York: Wiley and Sons, Inc., 1975.

3. Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., 1988.

4. McCarthy, Willard J., and Victor E. Repp. Machine Tool Technology. 4th ed. Bloomington, IL: McKnight Publishing Co., 1979.

B. Curriculum guides

1. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. This unit presents formulas and statements which can be applied by machinists. The student is referred to geometry textbooks for the logical basis for these formulas and statements. The instructor may want to explain the proof of one or more of these statements to illustrate geometric interrelationships.

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT IV: GEOMETRIC FIGURES AND FORMS

LESSON 1: ANGLES

I. Terms and definitions

A. Angle--space or form within two lines that come from a common point or within two planes diverging from a common line

B. Circle--set of points on a plane which are the same distance from a fixed, central point in the plane

C. Degree--defined as 1/360 of a complete rotation, 1/180 of a straight angle or 1/90 of a right angle

D. Geometric point--indicator of position. It has no length, width or thickness.

E. Geometry--mathematical science which studies space using points, lines and planes

F. Line--trace of a moving point (A straight line is the shortest distance between two points.)

G. Parallel lines--two straight lines in the same plane which never meet

H. Perpendicular--meeting at right angles (90°)

I. Plane--flat or level surface which is defined by length and width but has no thickness

J. Protractor--tool used to measure angles. It usually contains 180°.

II. Angle measurement

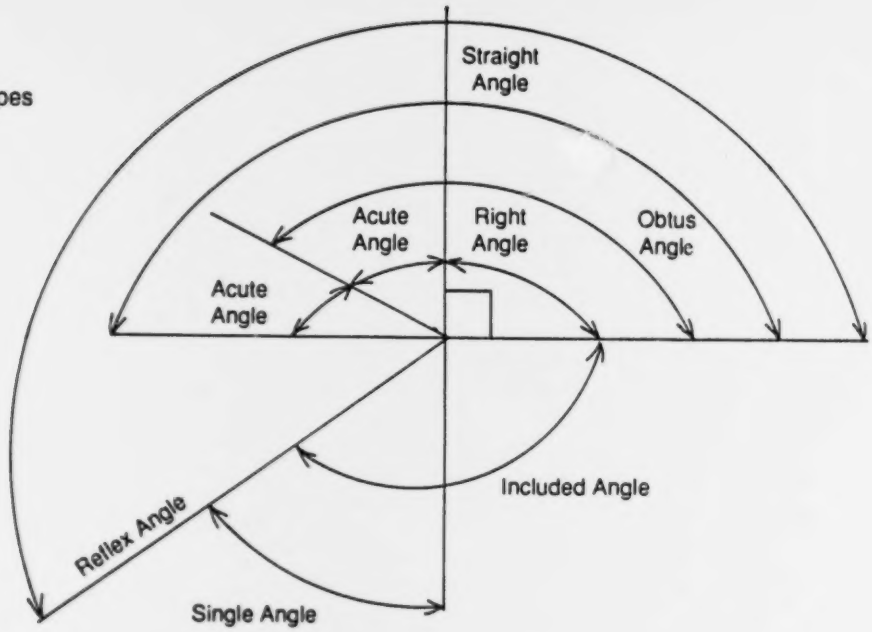
A. One way to think about an angle is to describe it as the amount of rotation of a line when one end of the line is fixed at a point.

B. By definition, a circle or complete rotation contains 360°.

1. Each degree can be divided into 60 minutes (60').

2. Each minute can be divided into 60 seconds (60").

III. Angle types



A. A right angle is a 90° angle or 1/4 of a rotation.

B. An acute angle is one which is less than 90°.

C. An obtuse angle is greater than 90° and less than 180°.

D. A straight angle is 180°.

E. A reflex angle is greater than 180° and less than 360°.

F. An included angle contains more than one angle.

IV. Angle relationships

A. Adjacent angles are angles having one common side.

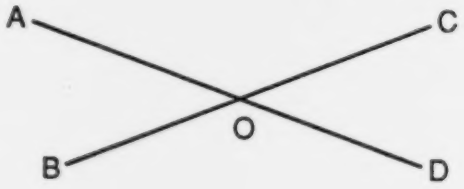
B. Complementary angles are two angles whose sum is a right angle.

C. Supplementary angles are two angles whose sum is a straight angle.

D. The sum of the inside angles of a triangle equal 180°.

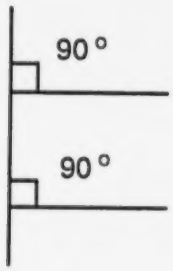
E. The sum of the inside angles of a square equal 360°.

F. When two straight lines intersect, the opposite angles are equal.

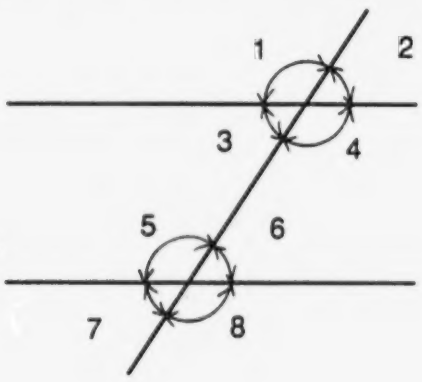


Angle AOB = Angle COD **and** Angle AOC = Angle BOD

G. If two lines in the same plane form right angles to the same line, they are parallel to each other.



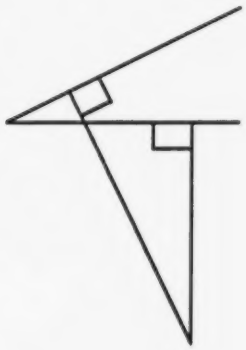
H. If two parallel lines are cut by a third line, the alternate interior angles are equal.



Angle 3 = Angle 6 (Angles 3, 2, 6 and 7 are all equal.)
Angle 5 = Angle 4 (Angles 1, 4, 5 and 8 are all equal.)

I. If the corresponding sides of angles are parallel, the angles are equal.

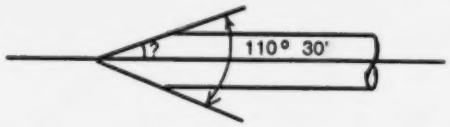
J. If the corresponding sides of angles are perpendicular, the angles are equal.



ANGLES

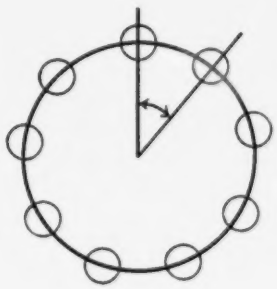
Compute answers to the following problems.

___ 1. A workpiece is to be turned on a lathe. At what angle to the centerline of the work must the compound rest be set to turn an included angle of 110° 30'?

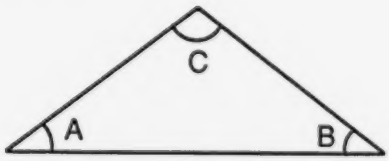


___ 2. What would the angle to centerline of #1 be if the included angle were 95°?

___ 3. A layout of nine holes, equally spaced on a circle, is shown below. What is the angle formed by connecting the centers of adjacent holes with the center?



Use the following artwork for questions 4-7.



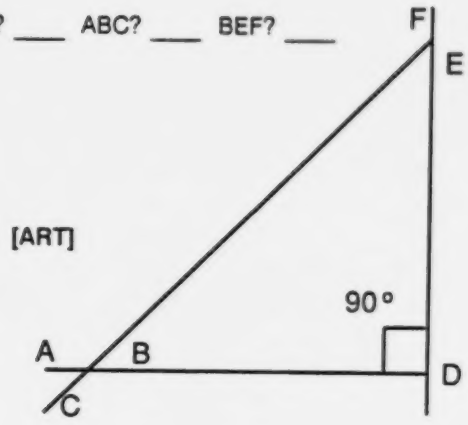
4. If angle A = 42° 40' and angle B = 40°, what is angle C? ___

5. If angle A = 51° 10' 5" and angle B = 35° 30', what is angle C? ___

6. Assume that sides AC and BC are equal in length. If angle C is 95°, what is angle A? ___
Angle B? ___

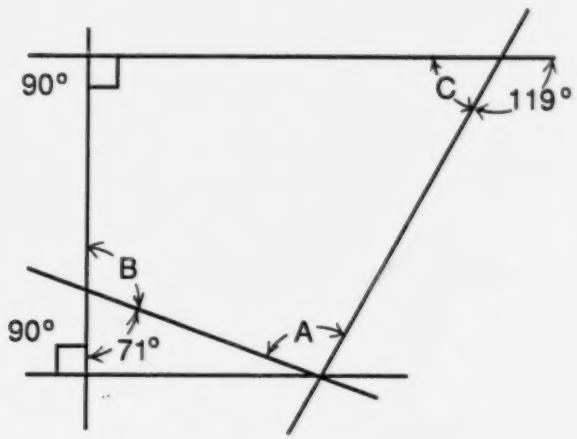
7. Assume that sides AC and BC are equal in length. If angle B is 38°, what is angle A? ___
Angle C? ___

8. If angle BED = 35°, what are angles EBA? ___ ABC? ___ BEF? ___



9. Determine the sizes of angles A, B and C in the following illustration.

A = ___ B = ___ C = ___



ANSWERS TO AS 1.1

1. 55° 15'
2. 47° 30'
3. 40°
4. 97° 20'
5. 93° 19' 55"
6. 42° 30', 42° 30'
7. 38°, 104°
8. 125°, 55°, 145°
9. A = 100°, B = 109°, C = 61°

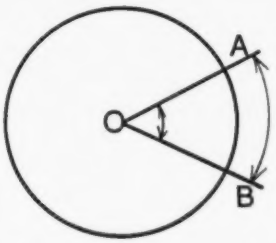
MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT IV: GEOMETRIC FIGURES AND FORMS

LESSON 2: POLYGONS, CIRCLES AND SOLIDS

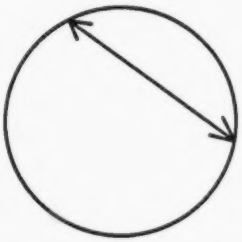
I. Terms and definitions

A. Arc--part of a curved line or circle which consists of two end points and the set of points on the circle between them. An arc can be measured by its length (part of the circumference) or by degrees which are the same as the degrees of the central angle.



B. Area--space within a boundary in a two-dimensional figure, expressed as square units

C. Chord--straight line which connects the two points of an arc or any two points on the circumference of a circle



D. Diameter--chord which passes through the center of a circle

E. Equilateral--sides of equal length

F. Perimeter--outer boundary of a two-dimensional figure

G. Pi (π)--ratio of a circle's circumference to its diameter. This ratio (approximately 3.1416) is the same for all circles.

H. Plane geometry--study of the figures such as the circle, triangle and square which lie in one plane

I. Polygon--closed plane figure having three or more straight sides

J. Solid geometry--study of figures such as the sphere, cylinder and cube that are three-dimensional and therefore not in one plane

K. Tangents--lines perpendicular to the radius of the circle at its outer extremity

II. Triangles are three-sided polygons.

A. Kinds of triangles

1. Right triangles contain one right angle.

   NOTE: Since the sum of all of the angles in a triangle is 180°, there can be only one right angle in a triangle; the sum of the acute angles of a right triangle is 90°.

2. Isosceles triangles have two equal sides, and the angles opposite these sides are equal.

3. Obtuse triangles contain one obtuse angle.

4. Oblique triangles contain no right angles.

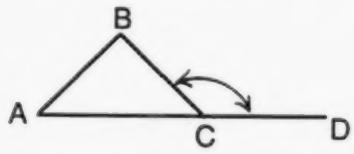
5. Acute triangles contain three acute angles.

6. An equilateral triangle contains three equal sides. (An equilateral triangle is also equiangular, which means that all angles are also equal.)

B. Triangle relationships

1. In triangles, angles cannot be changed without changing side lengths. Other polygons do not share this property.

2. The exterior angle formed by extending a line of a triangle is equal to the sum of the opposite interior angles. Angle DCB = Angle CAB + Angle ABC.



3. If two sides and the included angle of one triangle are equal to two sides and the included angle of another, the triangles are identical.

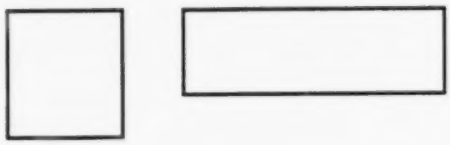
4. If two angles and the included side of one triangle are equal to two angles and the included side of another, the triangles are identical.

C. The perimeter of a triangle is determined by adding together the lengths of all three sides.

D. A triangle's area is determined by the formula: A = 1/2 bh in which A = area, b = the length of the base and h = height.

III. Quadrilaterals are four-sided polygons.

A. Rectangle

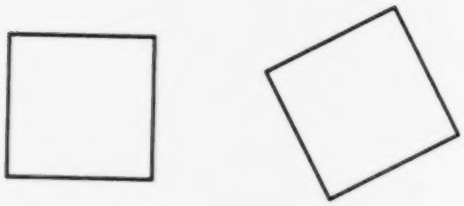


1. Rectangles are quadrilaterals in which the opposite sides are parallel and the sides form right angles to each other.

2. Perimeter is determined by the formula: $P = 2L + 2W$ (P = perimeter, L = length and W = width).

3. The area is determined by the formula: $A = L \times W$ in which A = area in square units.

B. Square

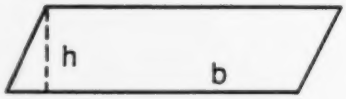


1. A square is an equilateral rectangle.

2. Perimeter is determined by the formula: $P = 4L$ in which P = perimeter and L = length of the sides.

3. The area is determined by the formula: $A = L^2$.

C. Parallelogram



1. A parallelogram is a quadrilateral in which opposite sides are parallel but not necessarily perpendicular. (Rectangles and squares are also parallelograms.)

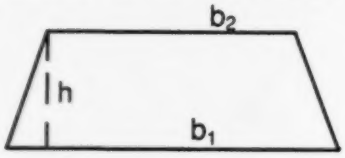
2. Perimeter is determined by the formula: $P = 2L + 2W$ in which P = perimeter, L = length of the longest sides and W = length of the shorter sides.

3. Area is determined by the formula: $A = bh$ in which A = area in square units, b = length of the base and h = height. (Remember that a parallelogram is two triangles, so 2 x [area of both triangles] or 2 [1/2 bh] is the area of the parallelogram.)

4. A rhombus is an equilateral parallelogram.

D. Trapezoid

1. Trapezoids are quadrilaterals in which two sides are parallel and two sides are not.



2. To find perimeter, add together the lengths of all sides.

3. Area is determined by the formula $A = 1/2\ h\ (b_1 + b_2)$ in which A = area in square units, b_1 = length of one of the parallel sides and b_2 = length of the other parallel side.

IV. Circles

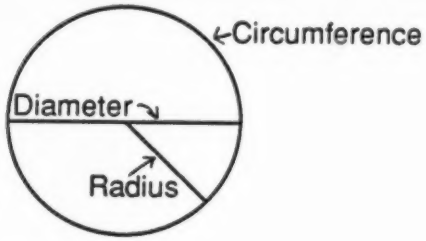
A. The perimeter of a circle is called its circumference.

B. The radius of a circle is the distance between the center to its edge. It is one-half the diameter.

C. A circle's circumference is estimated by the formula $C = \pi D$ or $C = 2\pi r$ (C = circumference, $\pi = 3.1416$ D = diameter, and r = radius).

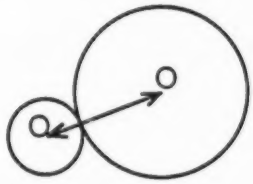
D. The radius or diameter of a circle can be determined by rearranging the circumference formula. $r = C/2\pi$ and $D = C/\pi$

E. A circle's area is determined by the formula $A = \pi r^2$ or $0.7854(D^2)$ in which A = area in square units, $\pi = 3.1416$, r = radius of the circle and D = diameter of the circle.

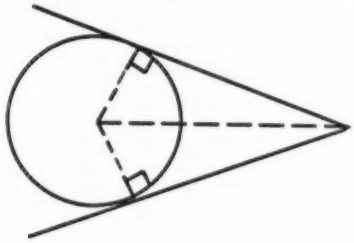


F. Circle relationships

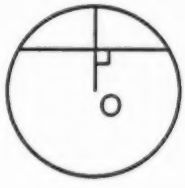
1. If two circles are tangent to each other externally, a line joining the centers will pass through the point of tangency and be equal to the sum of their radii.



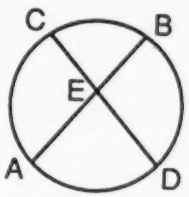
2. If two tangents are drawn from an external point to a circle, the lines are equal in length and a line from the circle's center to this external point forms two equal angles.



3. A line from the center of a circle that is perpendicular to a chord bisects that chord.



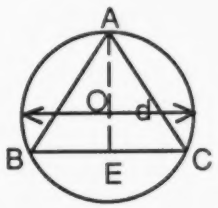
4. If two chords intersect within a circle, the product of the two segments of one equals the product of the two segments of the other.



$AE \times EB = CE \times ED$

G. Polygons inscribed in circles

1. Triangles--the product of two sides is equal to the product of the diameter of the circle and the altitude upon the third side.



$AC \times AB = AE \times d$

2. To determine the length of the side of an inscribed square, multiply the diameter by 0.7071 or the radius by 1.4142.

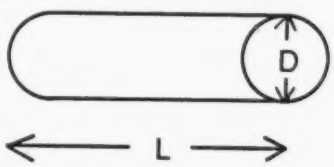
V. Rectangular solids

A. The volume of a rectangle is determined by the formula $V = L \times W \times H$ in which V = volume expressed as cubic units, L = length, W = width and H = height.

B. The volume of a cube is the sides cubed (to the third power).

VI. Cylinders (tubes)

A. The outside area of an open cylinder is approximated by the formula $A = \pi DL$ in which A = area in square units, $\pi = 3.1416$, D = diameter and L = length of the tube.



B. The area of a closed cylinder is the area calculated above plus 2 times the area of the ends. Therefore, $A = \pi DL + 2\ (.7854D^2)$.

C. The volume of the cylinder is approximated by multiplying the area of the end times the length. ($V = \pi r^2 L$) The answer is expressed as units cubed.

VII. Spheres

A. A sphere is defined as the set of all points in space at a given distance from a fixed point called the center.

B. The volume of a sphere is approximated by the formula:

$$V = \frac{\pi \times 4 \times r^3}{3}$$

VIII. Other polygons

A. Regular polygons are both equilateral and equiangular.

B. The sum of the interior angles of a polygon of n sides is determined by the following formula:

Sum of the angles in degrees = 180 (n-2)

C. Each interior angle of a regular polygon of n sides is determined by the formula:

$$\frac{(n-2)\ 180}{n}$$

D. Polygon names

1. Pentagon--five-sided polygon
2. Hexagon--six-sided polygon
3. Heptagon--seven-sided polygon
4. Octagon--eight-sided polygon
5. Nonagon--nine-sided polygon
6. Decagon--ten-sided polygon
7. Dodecagon--twelve-sided polygon

E. Polygon construction: Equilateral polygons can be obtained by equally spacing holes around a circle.

1. To space the holes accurately, the machinist can use either chords or horizontal and vertical distances.

2. Use of a chord constant table **(HO 2.1)**

a. The table lists chord constants for a diameter of 1 mm, 1", 1 m, etc.

b. To use the chart, select the constant for the number of divisions or holes and multiply by the diameter of the circle. The result is the length of the chord to be used.

Example: A machinist needs to make a cover plate with five evenly spaced holes. The bolt circle's diameter is 400 mm. What is the chord length needed? Solution: The chord constant is 0.5878 for five divisions. 400 mm x 0.5878 = 235.12 mm.

3. Holes on a circle can be located by measuring horizontal and vertical distances.

a. The starting point is the center of the circle.

b. The distances are constants times the circle's diameter.

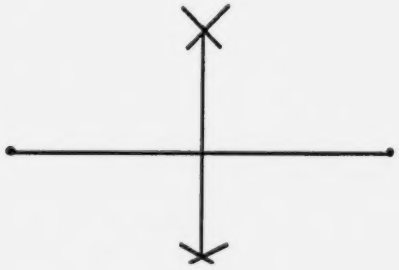
Example: To make a octagon that fits within a circle with a diameter of 200 mm, find the constants for an eight-hole circle **(HO 2.2)** and multiply by 200. The distances are: a = 29.3 mm, b = 70.72 mm and c = 100 mm.

IX. Simple geometric construction

A. Bisecting a line

1. Using a compass, make two sets of arcs using the same radius (one which is convenient and greater than one-half the distance of the line) which intersect each other on both sides of the line.

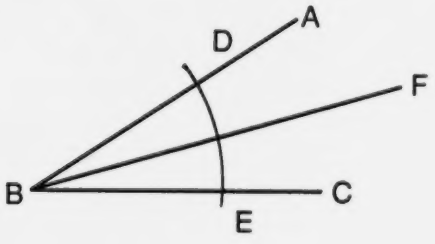
2. Connect the intersection points. The perpendicular line that is formed bisects the line.



B. Bisecting an angle

1. Make an arc cutting angle ABC at D and E.

2. Using D and E as centers, make arcs which meet at F. The line through B and F is the bisector of angle ABC.

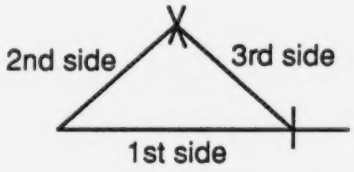


C. Construction of a triangle

1. Measure the first distance.

2. Make an arc (the radius will be the second distance).

3. Make a second arc (the radius will be the third distance from the other end of the first line). The intersection of these two arcs is the third point of the triangle.

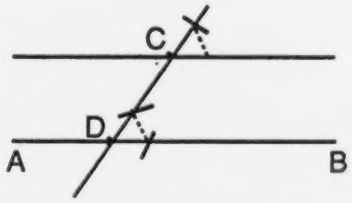


D. Construction of parallel lines

1. Given: Line AB and point C which is not on AB
   Required: A line through C which is parallel to AB

2. Draw any line through C which meets AB.

3. Construct a triangle at D and repeat the same one at C. A line through the point C and the intersection forms a parallel line.



CHORD CONSTANTS

The table lists the chord constants for unity (1 m, 1 cm, 1", etc.). Multiply the chord constant for the number of divisions or holes by the diameter of the circle. The result is the length of each chord.

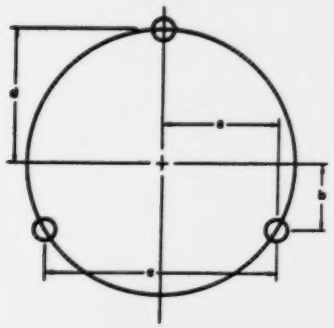
Divisions	Degree	Constant*
3	120°	0.8660
4	90°	0.7071
5	72°	0.5878
6	60°	0.5000
8	45°	0.3827
10	36°	0.3090
12	30°	0.2588
15	24°	0.2079
18	20°	0.1736
20	18°	0.1564
24	15°	0.1305
30	12°	0.1045
32	11.25°	0.0980
36	10°	0.0872

*Based on a hole diameter of 1 mm/1"

Credit: Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., © 1988, pg. 143. Reproduced by permission.

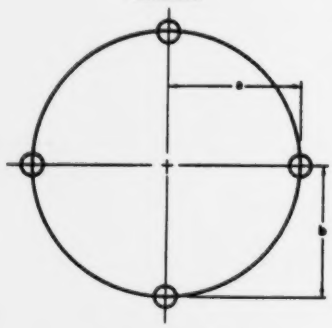
DISTANCE CONSTANTS FOR LOCATING HOLES ON A CIRCLE

3 HOLES



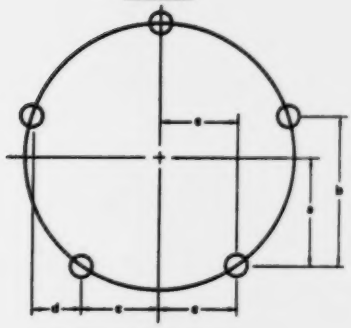
a = 0.4330 X D
b = 0.2500 X D
c = 0.8660 X D
d = 0.5000 X D

4 HOLES



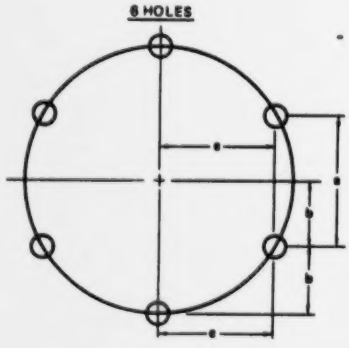
a = 0.5000 X D
b = 0.5000 X D

5 HOLES



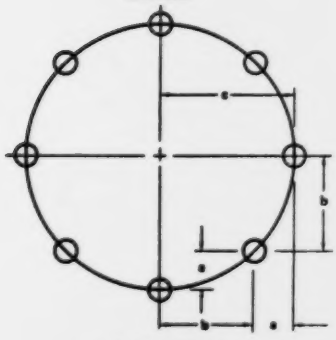
a = 0.4045 X D
b = 0.5590 X D
c = 0.2939 X D
d = 0.1816 X D

6 HOLES



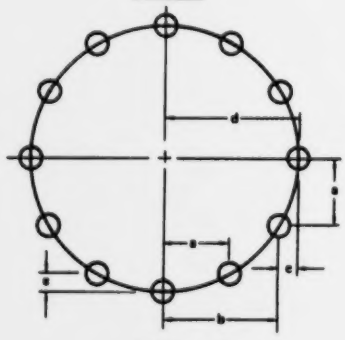
a = 0.5000 X D
b = 0.2500 X D
c = 0.4330 X D

8 HOLES



a = 0.1465 X D
b = 0.3536 X D
c = 0.5000 X D

12 HOLES



a = 0.2500 X D
b = 0.4330 X D
c = 0.06699 X D
d = 0.5000 X D

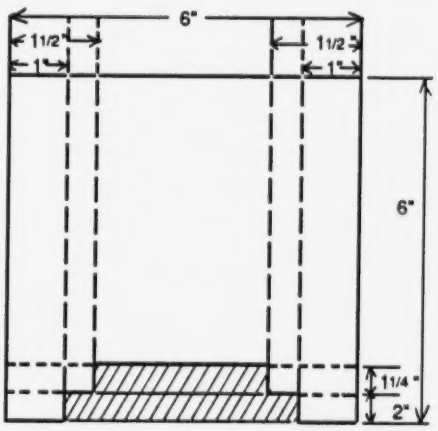
Credit: Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., © 1988, pg. 146 and 147. Reproduced by permission.

CALCULATING AMOUNT OF STOCK REQUIRED

Round answers to the nearest thousandth where necessary.

1. Rectangles made of sheet metal are 10 cm by 7 cm. In order to make six of these, how many square cm of sheet metal is needed? _____ How many square feet? _____

2. What is the total square inches of this piece of metal before being cut? _____ How many square inches were cut away? _____ What is the area of the cut piece?



A round hole is to be covered by a circular plate which fits inside the hole. The inside diameter of the hole is 4.5". It is cut from a 5" square piece.

3. What is the circumference of the hole? _____

4. What is the approximate area of the circular plate? _____

5. What is the area wasted? _____

6. Calculate the amount of metal needed for a open cylinder 45 cm in length and 25 cm in diameter. _____

7. Calculate the amount of metal needed for the same cylinder with closed ends. _____

8. How many of these open cylinders could be made from a piece of metal 100 cm by 80 cm? _____

9. How many of these closed cylinders could be made from the same piece of metal? _____

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B5: Calculate amount of stock required.

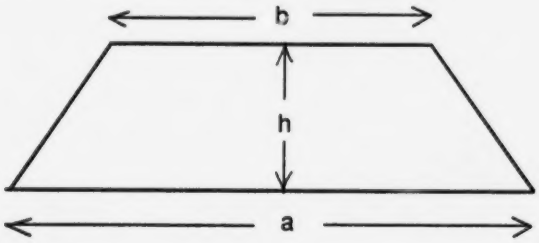
CALCULATING FEATURE DIMENSIONS AND AREAS

Round to the nearest thousandth where necessary.

___ 1. A piece of sheet metal measures 6 3/64" by 14 1/16". How many square inches does it have?

___ 2. A piece of sheet metal in the shape of a parallelogram is 35.9 cm high and 62.4 cm long. What is its area?

Determine the areas of each of the following trapezoids.

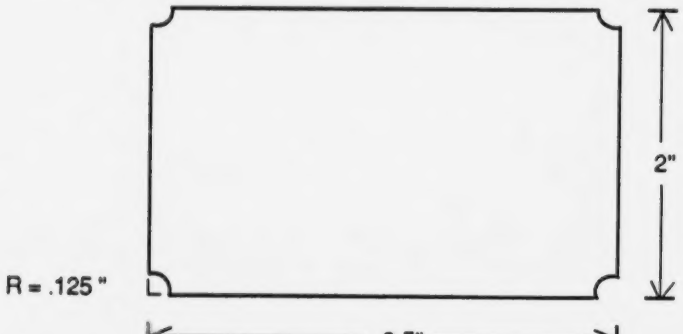


___ 3. a = 5.699"; b = 3.245"; h = 1.34"

___ 4. a = 3.211 m; b = 1.97 m; h = 0.5 m

___ 5. a = 405 mm; b = 320 mm; h = 422 mm

___ 6. What is the perimeter of the plate illustrated below?

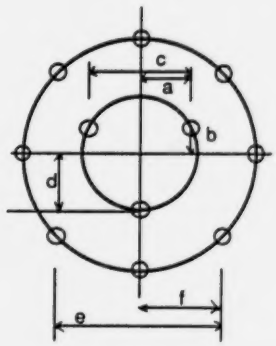


(Figure is symmetric)

___ 7. A washer has an outside diameter of 350 mm and an inside diameter of 300 mm. What is the area of the washer?

____ 8. A bolt circle has a diameter of 500 mm. There are 12 holes around the circle. What is the distance between the centers of the holes?

Determine the following dimensions. The diameter of the larger circle is 7.5". The diameter of the smaller circle is 3".



____ 9. Dimension a =

____ 10. Dimension b =

____ 11. Dimension c =

____ 12. Dimension d =

____ 13. Dimension e =

____ 14. Dimension f =

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B6: Calculate part feature dimensions and locations.

GEOMETRIC APPLICATIONS

___ 1. A shipper can accept boxes no higher than 6' and with a perimeter no greater than 16'. The box to be shipped is 4.75' high, 3.5' wide and 5.75' long. Will the shipper accept it? Show calculations.

What is the volume of spheres with the following diameters? (Round answers to the nearest ten-thousandth.)

___ 2. 12.75 mm

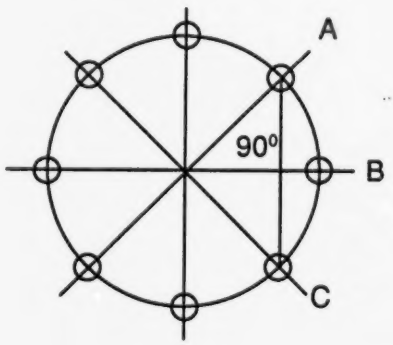
___ 3. 6.232 cm

___ 4. 2.25"

___ 5. What is the volume of a box that is 4.5' wide, 6.75' long and 3' high?

___ 6. How many cubic cm of steel are removed when a hole 3.54 cm in diameter is created in a 10 cm block of steel which is 3 cm thick?

___ 7. How many degrees is arc AB?



8. Construct a line segment parallel to line AB and 16 mm above it.

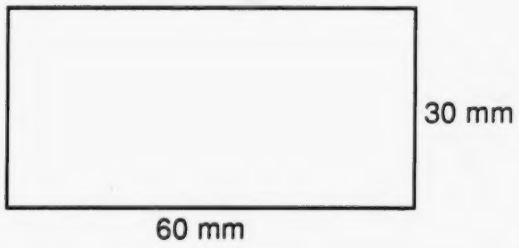
ART

9. Construct a line perpendicular to line AB at point x.

10. Bisect angle ABC.

11. Construct a triangle with sides 30 mm, 40 mm and 18 mm long.

12. Construct arcs at the four corners of this rectangle (rounding the corners) with a radius of 12 mm.



INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B13: Calculate plane geometry/math applications.

ANSWERS TO AS 2.1

1. 420 sq. cm, 0.452 sq. ft.
2. 36 sq. in., 11 3/4 sq. in., 24 1/4 sq. in.
3. 14.137 in.
4. 15.904 sq. in.
5. 9.096 sq. in.
6. 3534 sq. cm
7. 4515.75 sq. cm
8. 2
9. 1

ANSWERS TO AS 2.2

1. 85.034 in^2
2. 2240.16 cm^2
3. 5.992 in^2
4. 1.295 m^2
5. 152,975 mm^2
6. 16.785"
7. 25,525.5 mm^2
8. 129.4 mm
9. 1.299"
10. 0.75"
11. 2.598"
12. 1.5"
13. 5.304"
14. 2.652"

ANSWERS TO AS 2.3

1. No (perimeter = 18.5 ft.)
2. 1085.2509 mm^3
3. 126.7307 cm^3
4. 5.9641 $in.^3$
5. 91.125 $ft.^3$
6. 29.527 cm^3
7. 30°

8-12. To be evaluated by instructor

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT IV: GEOMETRIC FIGURES AND FORMS

UNIT TEST

Match definitions on the left with terms on the right.

____ 1.	Set of points on a plane which are the same distance from a fixed point	a.	Chord
____ 2.	Space or form within two lines that come from a common point	b.	Degree
____ 3.	1/360 of a complete rotation	c.	Line
____ 4.	Trace of a moving point	d.	Angle
____ 5.	Meeting at right angles	e.	Circle
____ 6.	Part of a curved line or circle which consists of two end points and the set of points between them	ab.	Pi
____ 7.	Straight line which connects any two points on the circumference of a circle	ac.	Perpendicular
____ 8.	Sides of equal length	ad.	Arc
____ 9.	Ratio of circle's circumference to its diameter	ae.	Equilateral

Choose the best answer to each question or problem. (pi = 3.1416)

____ 10. A degree is _____ .

a. 10 minutes
b. 100 minutes
c. 100 seconds
d. 60 minutes
e. 60 seconds

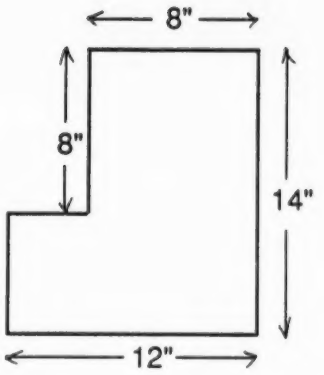
____ 11. An acute angle is _____ .

a. Less than 45 degrees
b. Less than 90 degrees
c. 90 degrees
d. Greater than 90 degrees
e. Greater than 180 degrees

____ 12. Two triangles are cut from a 25 cm square piece of sheet metal. One has a base of 10 cm and an altitude of 5 cm. The other has a base of 10 cm and an altitude of 7 cm. How many square cm of sheet metal are left after these triangles are cut?

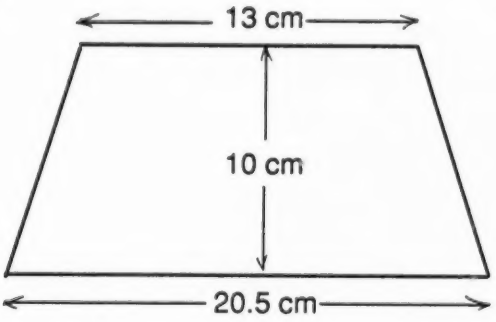
a. 60 cm^2
b. 600 mm
c. 565 cm^2
d. 625 cm^2
e. 385 cm^2

___ 13. The area of this plate is _____ .



a. 136 $in.^2$
b. 130 ft.
c. 28 $in.^2$
d. 168 $in.^2$
e. 14 ft.

___ 14. The area of this trapezoid is _____ .



a. 43.5 cm^2
b. 53.5 cm^2
c. 167.5 cm^2
d. 335 cm^2
e. 2665 cm^2

___ 15. The area of a 12" grinding wheel with a 2" center hole is _____ .

a. 31.416 $in.^2$
b. 109.956 $in.^2$
c. 439.823 $in.^2$
d. 452.39 $in.^2$
e. 13,975 $in.^2$

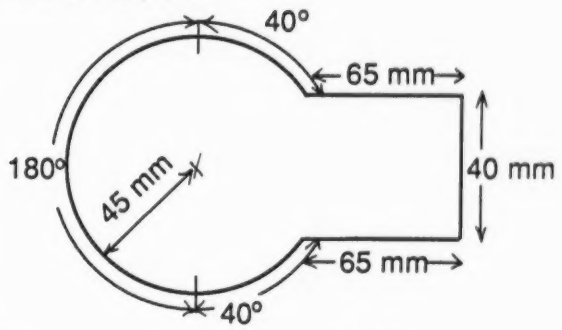
___ 16. The volume of a box measuring 4' by 3' by 2.5' is _____ .

a. 30 $ft.^3$
b. 17.5 $ft.^3$
c. 24 $ft.^2$
d. 9.5 $ft.^3$
e. 19 $ft.^2$

___ 17. How many cubic mm of metal is removed by boring a hole 60 mm in diameter through a piece of steel 40 mm thick?

a. 2400 mm^3
b. 3769.9 mm^2
c. 36,000 mm^3
d. 113,097.6 mm^3
e. 144,000 mm^3

___ 18. Find the perimeter of this piece.



a. 311.4 mm
b. 374.2 mm
c. 412.7 mm
d. 430 mm
e. 452.7 mm

___ 19. How much steel is needed to make an open cylinder 12" in length with a diameter of 6"?

a. 72 $in.^2$
b. 226.2 $in.^2$
c. 113.1 $in.^3$
d. 432 $in.^3$
e. 864 $in.^3$

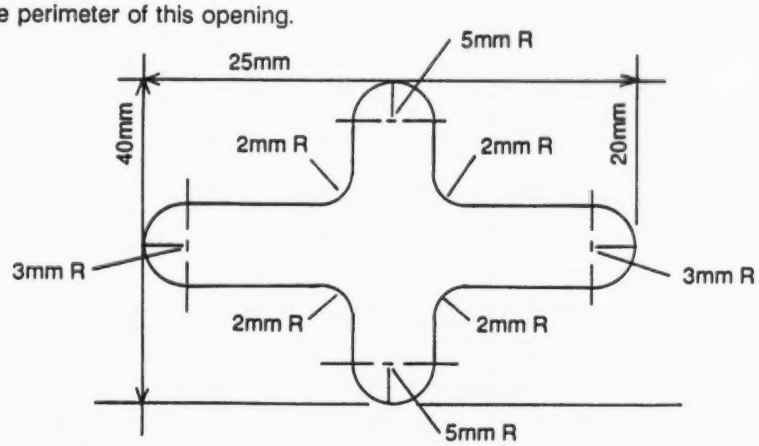
___ 20. A machinist needs to space eight holes around a bolt circle of 15 cm diameter. (The chord constant is 0.3827.) What is the distance between the centers of each hole?

a. 1.875 cm
b. 3.062 cm
c. 5.74 cm
d. 39.195 cm
e. 313.56 cm

___ 21. The figure formed by connecting the holes of the bolt circle in #20 is called a _____.

a. Pentagon
b. Nonagon
c. Heptagon
d. Octagon
e. Hexagon

___ 22. Find the perimeter of this opening.



a. 125.13 mm
b. 156.55 mm
c. 157.13 mm
d. 182.27 mm
e. 390 mm

ANSWERS TO UNIT TEST

1.	e	(B13)
2.	d	(B13)
3.	b	(B13)
4.	c	(B13)
5.	ac	(B13)
6.	ad	(B13)
7.	a	(B13)
8.	ae	(B13)
9.	ab	(B13)
10.	d	(B13)
11.	b	(B13)
12.	c	(B13)
13.	a	(B13)
14.	c	(B13)
15.	b	(B13)
16.	a	(B13)
17.	d	(B13)
18.	b	(B13)
19.	b	(B13)
20.	c	(B13)
21.	d	(B13)
22.	b	(B13)

MODULE: MACHINE SHOP ORIENTATION AND MATH
UNIT V: MATH APPLICATIONS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to determine tap drill sizes, use proportions to solve problems including those involving similar polygons and tapers, perform indexing calculations, and calculate feeds and speeds. This knowledge will be evidenced by achieving specified scores on assignment sheets and the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match tap terms with definitions.

1.2 Interpret descriptors of taps, dies and threading tools.

1.3 Calculate tap drill size with formulas and charts. (competency B2)

2.1 Match proportion and taper terms with definitions.

2.2 Identify and use ratios and proportions to solve common problems.

2.3 Apply proportions to the solution of problems involving similar polygons. (competency B13)

2.4 Calculate taper dimensions for machine set-up. (competency B9)

3.1 Perform direct and simple indexing calculations.

3.2 Perform angular indexing calculations. (competency B11)

4.1 Match rotational equipment terms with definitions.

4.2 Describe, determine and calculate cutting speeds. (competency B7)

4.3 Describe and calculate spindle speeds.

4.4 Determine milling feed rates. (competency B8)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

CONTENTS OF THIS UNIT

A. Objective sheet

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C. Lesson plans

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   a. Information outline
   b. Handout
      HO 1.1: Tap drill sizes (inches and millimeters)
   c. Assignment sheet
      AS 1.1: Tap drill sizes
   d. Answers to assignment sheet
2. Lesson 2: RATIOS, PROPORTIONS AND TAPERS
   a. Information outline
   b. Assignment sheet
      AS 2.1: Ratios and proportions
   c. Answers to assignment sheet
3. Lesson 3: INDEXING
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      AS 3.1: Indexing calculations
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4. Lesson 4: FEED AND SPEED CALCULATIONS
   a. Information outline
   b. Assignment sheet
      AS 4.1: Speed and feed requirements
   c. Answers to assignment sheet

D. Unit test

E. Answers to unit test

REFERENCES

A. Books

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Boyce, John G., Samuel Slade and Louis Margolis. Mathematics for Technical and Vocational Schools. 6th ed. New York: Wiley and Sons, Inc., 1975.

3. Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., 1988.

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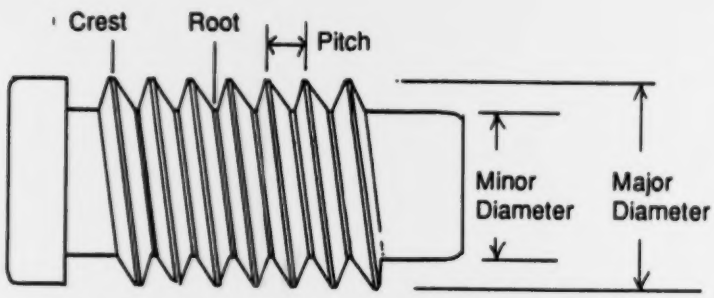
MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

LESSON 1: TAP DRILL SIZE CALCULATIONS

I. Terms and definitions

A. Diameter of threads--distance from the top of the crest on one side to the top of the crest on the other; also called the major or crest diameter.



B. Minor diameter--distance between roots; also called root diameter.

C. Pitch--distance from a point on a thread to the corresponding point on the adjacent thread (or spacing between threads)

D. Tap--cutting tool used for cutting a screw thread in a hole of specific size called a tap drill hole

E. Tap drill--standard twist drill of a specific size for a particular size and coarseness of screw thread

II. Form of descriptors for taps, dies and threading tools

A. ISO metric

1. The first letter of the descriptor, M, indicates that the tap size is metric.

2. The first number is the major diameter of the tap in mm.

3. The number after the "x" is the pitch of the tap.

Example: The descriptor M12 x 1.5 for a bolt means that it is metric; the outside diameter is 12 mm and the pitch is 1.5.

B. Unified and American (National)

1. The major diameter is indicated first in inches.

2. Threads per inch are indicated after the hyphen.

3. The thread series, Unified National coarse (UNC) or Unified National fine (UNF) is indicated after the threads per inch.

Example: The descriptor 3/8" - 16 UNC means that the diameter is 3/8 inches and there are 16 threads per inch. Pitch is the reciprocal of the threads per inch (1/16 in this example).

III. Determining tap drill size

A. The tap drill size is the size or diameter of the tap drill required for a given threaded hole.

B. There is a specific tap drill size for each thread size and pitch to produce the necessary percentage depth of the thread to be cut.

1. The tap drill sizes given in tables **(HO 1.1)** are based on threads which are approximately 75% of a full-depth thread.

a. This makes a hole that is larger than the minor diameter for a full-depth thread.

b. For most tapping requirements, a tap drill producing a minor diameter of 55-75% thread depth is adequate.

c. Tap drill sizes for threads of various percentage depths can be found in handbooks for machinists.

2. If a particular tap drill size is not available, the next larger size can be used. Tap drills smaller than the recommended size should not be used due to an increased danger of tap breakage.

C. Calculating tap drill sizes for ISO metric threads (approximately 75% thread depth)

1. Calculated by subtracting the pitch of the tap (mm) from the diameter

2. Example: Determine the tap drill size for an M25 x 2 thread.

Tap drill size = diameter - pitch = 25 - 2 = 23 mm

D. Calculating tap drill size for Unified and American (National) form threads (approximately 75% of the thread depth)

1. Calculated by subtracting the pitch from the major diameter in inches. The pitch is the reciprocal of the threads per inch.

2. Example: Calculate the tap drill size for a 1/2 - 20 UNF thread.

Tap drill size = 1/2 - 1/20 = 0.450 in.

The closest drill size is 0.4531 in. or 29/64 in.

TAP DRILL SIZES (INCHES)

TAP SIZE	PITCH	TAP DRILL	ALT. TAP DRILL mm	TAP SIZE	PITCH	TAP DRILL	ALT. TAP DRILL mm	TAP SIZE	PITCH	TAP DRILL	ALT. TAP DRILL mm
0	80 UNF	3/64	1.25	5/16	18 UNC	F	6.50	1¼	7 UNC	1 7/64	28.00
1	64 UNC	53	1.55		24 UNF	1	6.90		12 UNF	1 11/64	29.50
	72 UNF	53	1.55	3/8	16 UNC	5/16	8.00	1⅜	6 UNC	1 7/32	30.75
2	56 UNC	50	1.85		24 UNF	Q	8.50		12 UNF	1 19/64	32.75
	64 UNF	50	1.90	7/16	14 UNC	U	9.40	1½	6 UNC	1 11/32	34.00
3	48 UNC	47	2.10		20 UNF	25/64	9.90		12 UNF	1 27/64	36.00
	56 UNF	45	2.15	½	13 UNC	27/64	10.80	1¾	5 UNC	1 9/16	39.50
4	40 UNC	43	2.35		20 UNF	29/64	11.50	2	4 UNC	1 25/32	45.00
	48 UNF	42	2.40	9/16	12 UNC	31/64	12.20	TAPER PIPE TAPS NPT			
5	40 UNC	38	2.65		18 UNF	33/64	12.90	1/16	27 NPT	D	6.30
	44 UNF	37	2.70	5/8	11 UNC	17/32	13.50	⅛	27 NPT	R	8.70
6	32 UNC	36	2.85		18 UNF	37/64	14.50	¼	18 NPT	7/16	11.10
	40 UNF	33	2.95	¾	10 UNC	21/32	16.50	⅜	18 NPT	37/64	14.50
8	32 UNC	29	3.50		16 UNF	11/16	17.50	½	14 NPT	23/32	18.00
	36 UNF	29	3.50	⅞	9 UNC	49/64	19.50	¾	14 NPT	59/64	23.25
10	24 UNC	25	3.90		14 UNF	13/16	20.40	1	11½ NPT	1 5/32	29.00
	32 UNF	21	4.10	1	8 UNC	⅞	22.25	1¼	11½ NPT	1½	38.00
12	24 UNC	16	4.50		12 UNF	59/64	23.25	1½	11½ NPT	1 47/64	44.00
	28 UNF	14	4.70		14 UNS	15/16	23.50	2	11½ NPT	2 7/32	56.00
¼	20 UNC	7	5.10	1⅛	7 UNC	63/64	25.00	2½	8 NPT	2⅝	67.00
	28 UNF	3	5.50		12 UNF	1 3/64	26.50	3	8 NPT	3¼	82.50

Drill sizes based on approximately 72%–77% of full thread.

TAP DRILL SIZES (MILLIMETERS)

TAP SIZE mm	PITCH mm	TAP DRILL mm	ALT. TAP DRILL
ISO METRIC COARSE			
1.6	0.35	1.25	3/64
1.7	0.35	1.35	55
1.8	0.35	1.45	54
2	0.40	1.60	1/16
2.2	0.45	1.75	50
2.3	0.40	1.90	49
2.5	0.45	2.05	46
2.6	0.45	2.15	44
3	0.50	2.50	40
3.5	0.60	2.90	33
4	0.70	3.30	30
4.5	0.75	3.70	27
5	0.80	4.20	19
5.5	0.90	4.60	15
6	1.00	5.00	9
7	1.00	6.00	15/64
8	1.25	6.80	H
9	1.25	7.80	5/16
10	1.50	8.50	0
11	1.50	9.50	3/8
12	1.75	10.20	Y
14	2.00	12.00	15/32
16	2.00	14.00	35/64
18	2.50	15.50	39/64
20	2.50	17.50	11/16
22	2.50	19.50	49/64
24	3.00	21.00	53/64
27	3.00	24.00	61/64
30	3.50	26.50	1 3/64
33	3.50	29.50	1 5/32
36	4.00	32.00	1 1/4
36	4.00	35.00	1 3/8
ISO METRIC FINE			
3	0.35	2.65	37
4	0.35	3.65	27
4	0.50	3.50	29
4.5	0.45	4.05	21
5	0.50	4.50	16
5	0.70	4.30	18
5	0.75	4.25	18
5.5	0.50	5.00	9
6	0.50	5.50	7/32
6	0.75	5.25	5
7	0.75	6.25	D
8	0.50	7.50	M
8	1.00	7.00	J
9	0.50	8.50	Q
9	1.00	8.00	O
10	0.50	9.50	3/8
10	0.75	9.25	U
10	1.00	9.00	T
10	1.25	8.75	11/32
11	1.00	10.00	X
12	1.00	11.00	7/16
12	1.25	10.75	27/64
12	1.50	10.50	Z
13	1.50	11.50	29/64
13	1.75	11.25	7/16
14	1.25	12.75	1/2
14	1.50	12.50	31/64
15	1.50	13.50	17/32
16	1.00	15.00	19/32
16	1.25	14.75	37/64
16	1.50	14.50	9/16
18	1.00	17.00	43/64
18	1.25	16.75	21/32
18	1.50	16.50	41/64
18	2.00	16.00	5/8
20	1.00	19.00	3/4
20	1.50	18.50	47/64
20	2.00	18.00	45/64
22	1.00	21.00	53/64
22	1.50	20.50	13/16
22	2.00	20.00	25/32
24	1.00	23.00	29/32
24	1.50	22.50	7/8
24	2.00	22.00	55/64
24	2.50	21.50	27/32

Credit: SKF & Dormer Tools, Limited

DETERMINE TAP DRILL SIZES

Determine tap drill sizes for the following metric threads by calculation and use of HO 1.1.

	Calculation	HO 1.1
1.	M10 x 1.5	
2.	M6 x 1	
3.	M12 x 1.75	
4.	M16 x 1.25	

Determine the tap drill sizes for the following American standard threads by calculation and use of HO 1.1.

5. 5/8 - 11UNC
6. 1/2 - 13UNC
7. 5/16 - 24UNF
8. 1 1/8 - 12UNF

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B2: Calculate tap drill size with formula and charts.

ANSWERS TO AS 1.1

	Calculation	Handout
1.	8.5 mm	8.5 mm
2.	5 mm	5 mm (alternate: 9)
3.	10.25 mm	10.2 mm (alternate: Y)
4.	14.75 mm	14.75 mm (alternate: 37/64)
5.	0.5341 or 17/32	17/32 (alternate: 13.5 mm)
6.	0.4231 or 27/64	27/64 (alternate: 10.8 mm)
7.	0.2708 or 17/64	1 (alternate: 6.9 mm)
8.	1.0417 or 1 3/64	1 3/64 (alternate: 26.5 mm)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

LESSON 2: RATIOS, PROPORTIONS AND TAPERS

I. Terms and definitions

A. Proportion--two ratios that are equal

B. Tapering--basic lathe operation in which work is revolved and excess material removed either from the outside diameter or from the inside diameter by a tool bit moving at an angle to the work's centerline

C. Taper--a piece which changes in diameter or width at a constant rate for a part of its length

D. Total taper--difference in diameters of the large and small taper ends

II. Ratios and proportions

A. Ratio

1. Comparison of one quantity to another quantity.

Example: The ratio of A to B might be expressed as A:B = 2:1. This means that A is two times as much as B.

2. The ratio of two numbers is the quotient.

B. Equations involving ratios and proportions are useful in solving many problems.

Example: The ratio 4:1 can also be written 16:4. Therefore 4:1 = 16:4. This can also be written as 4/1 = 16/4. This is a direct proportion.

C. Direct proportion equations can be used to solve problems involving ratios.

Example: If a machine shop can make 45 parts in three hours, how many can be made in five hours?

1. Step 1: Set up the proportion.

$$\frac{45 \text{ parts}}{3 \text{ hours}} = \frac{x \text{ parts}}{5 \text{ hours}}$$

or $$\frac{3 \text{ hours}}{5 \text{ hours}} = \frac{45 \text{ parts}}{x \text{ parts}}$$

NOTE: Either equation gives the same answer. When setting up the equation, look to see that both sides are truly equal and that units are equivalent.

2. Step 2: Cross-multiply to solve the equation.

$3x = 5 \times 45 = 225$
$x = 75$ (Divide both sides by 3)

D. Use proportions to convert fractions of degrees to minutes or seconds.

$$\frac{1 \text{ degree}}{60 \text{ minutes}} = \frac{\text{degrees expressed as a fraction}}{x \text{ minutes}}$$

Example: How many minutes is 0.75°?

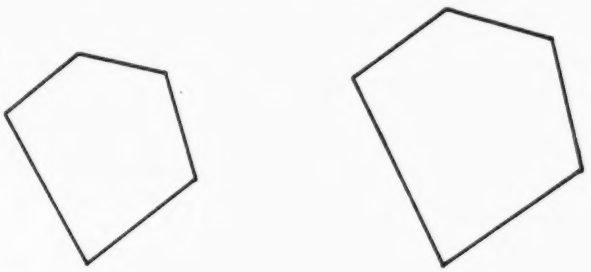
Solution: $\frac{1}{60} = \frac{.75}{x}$ or $x = 45'$

Seconds can be determined in the same way.

NOTE: To convert minutes and seconds to decimal degrees, divide the seconds by 60; add to the minutes; then divide the minutes by 60 and add to the degrees.

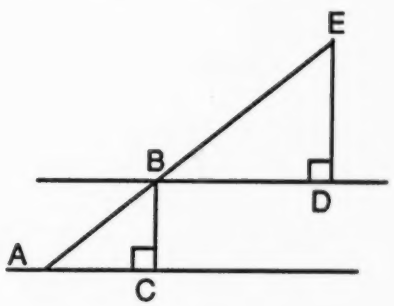
III. Similar polygons

A. Similar polygons have corresponding angles that are equal and corresponding sides that are proportional.



1. The ratio of any two corresponding sides is the same for all sides of similar polygons.
2. Perimeters of two similar polygons have the same ratio as any two corresponding sides.
3. The ratio of the areas of two similar polygons are the same as the ratios of the squares of any two corresponding sides or the ratios of the squares of their perimeters.

B. The general principles for similar polygons can be used with triangles to determine lengths and angles.

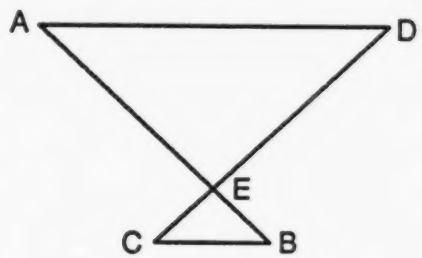


1. Since the corresponding angles in these right triangles are equal, these triangles are similar.

   $$\frac{AB}{BE} = \frac{AC}{BD} = \frac{CB}{DE}$$

2. Thus, if the lengths of two of the sides of one triangle and one of the corresponding sides of the other triangle are known, the proportion can be solved for all other sides.

C. If AD and CB are parallel, triangles AED and CEB are similar and proportional.



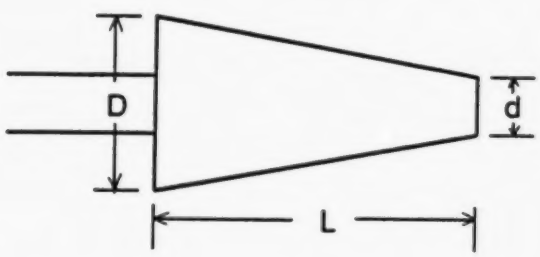
IV. Tapers

A. A taper is expressed as a ratio.

1. In metric measures, 1:20 would mean 1 mm per 20 mm of length.

2. In inch measures, tapers are expressed as inches per inch of length (tpi--taper per inch) or inches per foot of length (tpf--taper per foot).

B. Solving taper problems



1. If the amount of taper in a given length is known, the amount of taper in any length or the length to taper a certain amount can be determined by setting up a proportion.

   Example: A piece tapers 0.75" in 3" of length. How long must the piece be to taper 1.5"?

   $$\frac{0.75}{3} = \frac{1.5}{x}$$ Solve for x, which equals 6 inches.

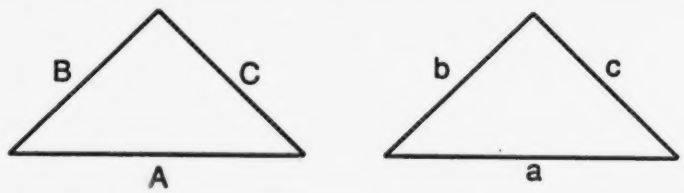
2. The diameter of one end of a taper can be determined if the diameter of the other end is known.

   $D = d + (L \times tpi)$ and $d = D - (L \times tpi)$

   D = larger diameter in inches
   d = smaller diameter in inches
   L = length in inches
   tpi = taper per inch

RATIOS AND PROPORTIONS

The two triangles below are proportional to each other--A:a = B:b = C:c. Using the lengths of the sides that are given, find the unknown length.



1. A = 65 mm, B = 55 mm, b = 10 mm, a = _____

2. C = 5.679 inches, A = 2.134 inches, c = 1.798 inches, a = _____

3. B = 6.5 cm, C = 9.3 cm, c = 7.2 cm, b = _____

4. A truck travels 157.5 miles in three hours. If the same speed is maintained, how far will it travel in 4.5 hours?

Convert the following to degrees, minutes and seconds (to the nearest second).

5. 90.425° = _____

6. 45.892° = _____

7. 126.233° = _____

8. The taper of a piece is three-quarter inch per foot. What is its length when the total taper is 0.0444 inch? _____

9. Find the length of a taper which is 0.378 inches larger at one end than at the other. It tapers at the rate of one inch per foot. _____

A workpiece tapers at the rate of one-half inch per foot. Find each unknown quantity below. D = larger diameter, d = smaller diameter and L = length. (Round answers to the nearest ten-thousandth inch, where necessary.)

10. D = 0.525 inch, d = 0.375 inch, L = _____

11. d = 0.1775 inch, L = 1.5 inches, D = _____

12. D = 1.25 inches, L = 3 inches, d = _____

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B9: Calculate tapers for machine set-up and B13: Calculate plane geometry/math applications.

ANSWERS TO AS 2.1

1. 11.8 mm
2. 0.676"
3. 5.0 cm
4. 236.25 miles
5. 90°25'30"
6. 45°53'31"
7. 126°13'59"
8. 0.0592' or 0.710"
9. 0.378' or 4.536"
10. 3.6000"
11. 0.2400"
12. 1.1250"

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

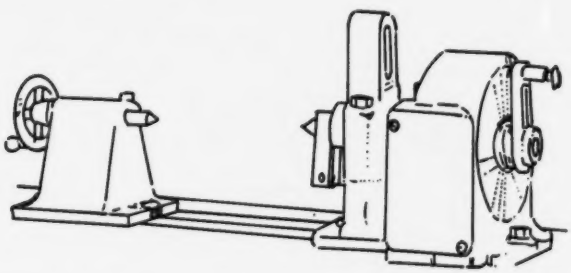
LESSON 3: INDEXING

I. Indexing--milling method used to accurately divide a circle's circumference into equal parts, as in the cutting of gear teeth on a gear

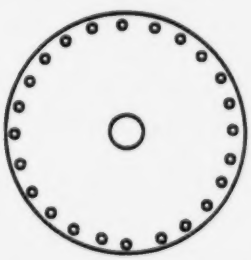
A. Plain or direct indexing connects the index crank directly to the spindle.

1. The crank and spindle are rotated directly to the required number of equal parts of the circle.

2. The number of possible equal divisions of the circle is determined by the number of holes on the index plate.



a. With a 24-hole plate (the most common), a circle can be divided into 2, 3, 4, 6, 12 and 24 equal cuts. (Each of these numbers will divide 24 equally.)



b. Other common direct indexing plates contain 30, 36, 48 and 60 holes.

3. To determine the number of holes to rotate the crank for each cut, divide the circle's number of holes by the number of cuts.

Example: How many holes would the crank be moved to make six cuts when using a 24-hole circle? Solution: 24 ÷ 6 = 4 holes for each of 6 cuts

B. Simple indexing for divisors of 40

1. The index crank turns 40 times to every one turn of the spindle. Thus, the ratio is 40:1.

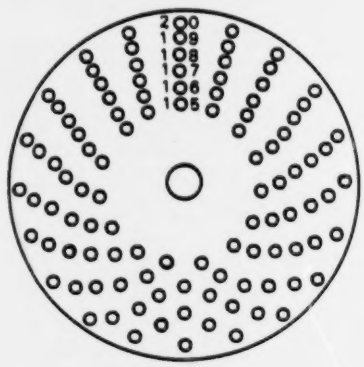
2. To determine the number of turns of the crank per cut, use the following proportion:

$$\frac{40}{\text{number of turns of the crank}} = \frac{\text{number of cuts or divisions}}{1 \text{ (whole circle)}}$$

Examples: For four cuts or divisions, 10 turns of the crank would be required for each cut. An octagon (eight divisions) would require five turns.

C. An indexing plate is used to accurately divide fractional parts of a turn.

1. The plates have a series of holes and come in various sizes.



2. When the number of turns is a whole number, any number of holes can be used.

3. When the number of turns calculated contains a fraction, the plate and number of holes to be used depends upon the fraction.

a. Select a plate in which the number of holes is a multiple of the denominator of the fraction.

b. Select the plate with the least number of holes that meets the condition.

c. Use the proportion below to determine the number of holes to accurately divide the turn.

$$\frac{\text{fraction numerator}}{\text{fraction denominator}} = \frac{\text{number of holes to turn the crank}}{\text{number of holes in the plate}}$$

Example: For 30 cuts, the number of turns of the crank calculated is 1 1/3. To turn one-third turn, the holes must be a multiple of 3. If plate A has 15, 16, 17, 18, 19 and 20 holes and plate B has 21, 23, 27, 29, 31 and 33 holes, both could be used because 15, 18, 21 and 33 are all multiples of 3. However, plate A is the best choice because it has the least number of holes. The 15-hole plate is selected. Then use the proportion:

$$\frac{1}{3} = \frac{x}{15} \qquad x = 5 \text{ holes}$$

II. Angular indexing

A. Forty turns of the crank will move the spindle 360° or one revolution. Therefore, each turn will move the spindle 9°.

B. To index for a certain number of degrees, set up the following proportion.

$$\frac{\text{degrees}}{9} = \frac{\text{number of holes to turn the crank}}{\text{number of holes on an existing hole circle}}$$

C. Choose the smallest hole circle that will make the number of holes to turn the crank a whole number.

INDEXING CALCULATIONS

Complete the following simple indexing chart using the following indexing plates. Plate A has 15, 16, 17, 18, 19 and 20 holes; Plate B has 21, 23, 27, 29, 31 and 33 holes; Plate C has 37, 39, 41, 43, 47 and 49 holes.

Divisions or cuts required	Number of turns of crank	Number of holes in indexing plate	Number of holes/cut
1. 6			
2. 11			
3. 23			
4. 36			
5. 54			
6. 220			

Complete the following angular indexing chart using the same indexing plates listed above.

Degrees	Number of turns of crank	Number of holes in indexing plate	Number of holes/cut
7. 45°			
8. 30°			
9. 12.5°			
10. 7°			
11. 5.5°			
12. 4.33°			

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B11: Perform angular and simple indexing calculations.

ANSWERS TO AS 3.1

1. 6 2/3, 15, 10
2. 3 7/11, 33, 21
3. 1 17/23, 23, 17
4. 1 1/9, 18, 2
5. 20/27, 27, 20
6. 2/11, 33, 6
7. 5
8. 3 1/3, 15, 5
9. 1 7/18, 18, 7
10. 7/9, 18, 14
11. 5 11/18, 18, 11
12. 4 13/27, 27, 13

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

LESSON 4: FEED AND SPEED CALCULATIONS

I. Terms and definitions

A. Cutting speed--rate that a point on the moving surface travels; expressed in either feet per minute (fpm) or meters per minute (mpm).

B. cfs (cutting foot speed) or sfpm (surface feet per minute)--rate at which material can be removed by a blade or other tool; rate at which the workpiece travels past the cutting tool

C. rpm (revolutions per minute)--rotational speed of a rotating object (number of times it completes a turn in one minute)

D. Spindle speed--number of times that the tool makes a revolution per minute, expressed as rpm

II. Determining cutting speed or surface feet per minute (sfpm)

A. The same basic formulas are used for lathes and cylindrical cutting tools (such as drills, taps, reamers, counter-boring tools and milling cutters).

B. Identifying a cutting speed

1. Circumferential speed of a milling cutter or drill and sfpm of the workpiece when working with a lathe

2. Factors affecting the selection of a cutting speed

a. Material being machined

b. Cutting tool type and material

c. Cutting fluid use and type

d. Quality of the finish

e. Machine set-up

3. Recommended average cutting speeds for various materials are found in tables in machinists handbooks.

a. Average cutting speeds are adjusted according to the conditions and the results produced.

b. A cutting speed that is too high can cause overheating and excessive wearing of the tool, while a speed that is too low can be inefficient.

C. Calculation of cutting speed when rpms are known

1. Generally, the cutting speed is determined from tables and experience, but it may be necessary for a machinist to calculate it when the rpms are known.

2. Metric formula for cutting speed

$$c.s. = \frac{D\ (mm) \times \pi \times rpm}{1000}$$

Cutting speed is in meters per minute.

3. Inch formulas for cutting speed

$$c.s. = \frac{D'' \times \pi \times rpm}{12} \quad \text{or} \quad c.s. = \frac{D'' \times rpm}{4}$$

Cutting speed is in feet per minute.

NOTE: The second formula is an approximation that is easy to remember. It is derived by dividing π (3.1416) by 12.

4. D is the diameter of the part that is rotating.

   a. Diameter of the drill or reamer when drilling or reaming

   b. Diameter of the cutter when milling

   c. Diameter of the workpiece or the hole when turning or boring on a lathe. Cutting speed for turning or boring refers to the rate at which the tool removes the stock from the surface.

III. Determining spindle speed

A. After the cutting speed is selected, it is necessary to determine the rpm setting of the machine spindle.

B. Calculation of speed

1. Metric formula for calculating spindle speed

$$rpm = \frac{c.s.\ (mpm) \times 1000}{D\ (mm) \times \pi}$$

2. Inch formulas for calculating spindle speed

$$rpm = \frac{c.s\ (fpm) \times 12}{D'' \times \pi} \quad \text{or} \quad rpm = \frac{4 \times c.s.\ (fpm)}{D''}$$

IV. Determining feed rate for milling

A. Feed is the rate at which the work is moved past the cutter.

B. In some milling machines, the feed rate increases proportionately as the spindle or cutter rpm increases, unless the feed rate is reset.

Example: Doubling the rpm without resetting the feed rate would double the feed rate.

C. The feed rate can be set independently of spindle rpm on most large milling machines. (A change in spindle speed does not affect the feed rate.)

D. Calculation of feed rate setting

1. Select the desired cutting speed from tables and considering the various factors and conditions.

2. Determine the rpm of the cutter.

3. Count the number of teeth in the cutter.

4. Select the amount of feed per tooth from table values.

5. Calculate feed rate (F).

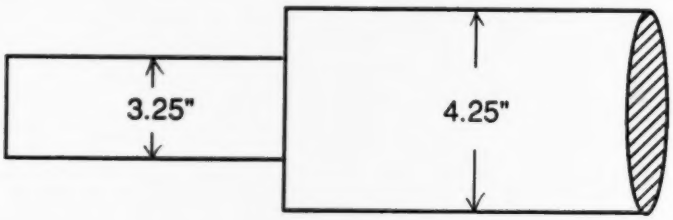
$$F \text{ (mm per min)} = R \times T \times rpm$$

R = feed per tooth per revolution in mm
T = number of teeth

SPEED AND FEED REQUIREMENTS

Determine the rpm setting for the following conditions. (Express answers to the nearest whole number.)

1. cfs = 95; D = 1.5"
2. cfs = 50; D = 1.75"
3. cfs = 110; D = 1.2"
4. mpm = 24; D = 50 mm
5. mpm = 80; D = 105 mm
6. mpm = 240; D = 175.5mm
7. The cylinder below is being turned at a surface speed of 50 fpm. What rpm is needed for the larger step? _____ The smaller step? _____ (Express answers to the nearest whole number.)



Calculate the cutting speed for the following situations. (Express answers in the nearest whole number.)

8. rpm = 200; D = 2"
9. rpm = 230; D = 0.75"
10. rpm = 125; D = 1.25"
11. rpm = 600; D = 40.2 mm
12. rpm = 280; D = 20.5 mm
13. rpm = 200; D = 60.1 mm
14. If a part is machined at 40 m/min at 100 rpm, what is the diameter of the part to the nearest hundredth mm? _____

Calculate the feed rate for a cutter with 18 teeth given the following conditions.

____ 15. c.s. = 30 mpm
suggested feed per tooth = 0.05 mm
diameter = 75 mm

____ 16. c.s. = 21 mpm
suggested feed per tooth = 0.10 mm
diameter = 100 mm

____ 17. c.s. = 60 mpm
suggested feed per tooth = 0.10 mm
diameter = 25.4 mm

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B7: Convert revolutions per minute (rpm) to surface feet per minute (sfpm).

ANSWERS TO AS 4.1

1. 242 rpm
2. 109 rpm
3. 350 rpm
4. 153 rpm
5. 243 rpm
6. 435 rpm
7. 45 rpm; 59 rpm
8. 105 fpm
9. 45 fpm
10. 41 fpm
11. 76 mpm
12. 18 mpm
13. 38 mpm
14. 127.32 mm
15. 115 mm/min.
16. 120 mm/min.
17. 1353 mm/min.

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT V: MATH APPLICATIONS

UNIT TEST

Match the definitions on the left with the terms on the right.

____ 1.	Distance from a point on a thread to the corresponding point on the adjacent thread	a.	cfs
____ 2.	Piece which changes in diameter at a constant rate for part of its length	b.	Indexing
____ 3.	Method to accurately divide the circumference of a circle	c.	Pitch
____ 4.	Number of feet that a point on a moving surface travels per minute in milling	d.	Proportion
____ 5.	Two ratios that are equal	e.	Tap
____ 6.	Lathe operation in which the tool bit moves at an angle to the centerline of the work	ab.	Taper
____ 7.	Tool used for cutting a screw thread	ac.	Tapering

Choose the best answer to each question or problem.

____ 8. The descriptor M8 x 0.5 for a bolt indicates that the pitch is _____ .

a. 8
b. 0.125
c. 0.5
d. 5
e. 2

____ 9. The descriptor 9/16 - 12UNC indicates that the pitch is _____ .

a. 9/16
b. 1 7/9
c. 12
d. 1/12
e. 11 5/12

____ 10. The calculated tap drill size for an M36 x 4 thread is _____ .

a. 32 mm
b. 4 mm
c. 36 mm
d. 144 mm
e. 4 cm

____ 11. The calculated tap drill size for a 3/8 - 16UNC thread is _____.

a. 3/8 in.
b. 5/16 in.
c. 1/16 in.
d. 15 5/8 in.
e. 16 in.

___ 12. Two rectangles are similar (proportional). If the dimensions of one are 30 mm by 10 mm and the smaller side of the smaller rectangle is 2.5 mm, what is the length of the longer side?

a. 0.83 mm
b. 7.5 mm
c. 12 mm
d. 75 mm
e. 83 mm

___ 13. If a taper's smaller diameter is 1 cm, taper per cm is 0.5 cm and length is 2.5 cm, what is the larger diameter of the taper?

a. 1.25 cm
b. 1.5 cm
c. 2.0 cm
d. 2.25 cm
e. 2.5 cm

For questions 14-16, assume that the dividing head has a 40:1 ratio.

___ 14. In simple indexing, the crank turns _____ times to every one turn of the spindle.

a. 1
b. 20
c. 25
d. 30
e. 40

___ 15. Which index-plate hole circle would be used to make 32 divisions?

a. 16
b. 18
c. 20
d. 32
e. 40

___ 16. In angular indexing, each turn of the crank moves the spindle _____ .

a. 5°
b. 9°
c. 10°
d. 15°
e. 30°

___ 17. The selection of the cutting speed is influenced by _____ .

a. The quality of the finish desired
b. The material being machined
c. The type of cutting tool
d. None of the above
e. All of the above

___ 18. The formula for determining cutting speed when the rpm is known is _____ .

a. $c.s. = \frac{rpm \times \pi \times D"}{12}$

b. $c.s. = \frac{\pi \times D"}{12 \times rpm}$

c. $c.s. = \frac{F \times rpm}{D" \times 12}$

d. $c.s. = \frac{rpm}{D" \times \pi}$

e. None of the above

___ 19. The rpm setting for the spindle of the milling cutter can be determined when one knows the _____.

a. Diameter of the spindle and the feed rate
b. Cutting speed and the type of material being milled
c. Circumference of the rotating part and the cutting speed
d. Diameter of the rotating piece and the length of the piece
e. None of the above

___ 20. Which of the following is <u>not</u> needed to determine the milling feed rate?

a. Feed per tooth
b. Time to cut the material
c. Number of teeth in the cutter
d. rpm
e. None of the above

ANSWERS TO UNIT TEST

1.	c	(B2)	11.	b	(B2)
2.	ab	(B9)	12.	b	(B13)
3.	b	(B11)	13.	d	(B9)
4.	a	(B8)	14.	e	(B11)
5.	d	(B13)	15.	c	(B11)
6.	ac	(B9)	16.	b	(B11)
7.	e	(B2)	17.	e	(B8)
8.	c	(B2)	18.	a	(B8)
9.	d	(B2)	19.	c	(B8)
10.	a	(B2)	20.	b	(B8)

MODULE: MACHINE SHOP ORIENTATION AND MATH
UNIT VI: RIGHT TRIANGLES

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to define and use trigonometric functions and the Pythagorean Theorem, solve problems with right and oblique triangles, and use trigonometric principles to determine angles of tapers and sine-bar set-ups. This knowledge will be evidenced by achieving specified scores on assignment sheets and the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match trigonometric terms with definitions.

1.2 Define the six trigonometric functions.

1.3 Determine the value of trigonometric functions using a calculator or table.

1.4 Solve for unknown parameters in right triangles using trigonometric functions.

1.5 Define and use the Pythagorean Theorem. (competency B12)

1.6 Solve for unknown parameters in oblique triangles. (competency B6)

2.1 Determine the angles of tapers. (competency B9)

2.2 Calculate sine-bar set-ups. (competency B10)

MODULE: MACHINE SHOP ORIENTATION AND MATH

UNIT VI: RIGHT TRIANGLES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TRIGONOMETRY

   a. Information outline

   b. Transparency master

      TM 1.1: Trigonometry memory aid

   c. Handouts

      HO 1.1: Right angle formulas
      HO 1.2: Trigonometric functions

   d. Assignment sheets

      AS 1.1: Degrees and function values
      AS 1.2: Dimensions and angles of right triangles
      AS 1.3: Dimensions and angles of oblique triangles

   e. Answers to assignment sheets

2. Lesson 2: TRIGONOMETRY APPLICATIONS

   a. Information outline

   b. Assignment sheets

      AS 2.1: Taper-angle calculations
      AS 2.2: Sine-bar calculations

   c. Answers to assignment sheets

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Boyce, John G., Samuel Slade and Louis Margolis. Mathematics for Technical and Vocational Schools. 6th ed. New York: Wiley and Sons, Inc., 1975.

3. Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., 1988.

4. McCarthy, Willard J., and Victor E. Repp. Machine Tool Technology. 4th ed. Bloomington, IL: McKnight Publishing Co., 1979.

B. Curriculum guides

1. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Trigonometric functions and applications have been presented in this unit without proofs. The instructor may wish to illustrate the proof of the trigonometric ratios to show how trigonometry develops naturally from geometry axioms and theorems.

B. Suggested student activities

1. When performing calculations in AS 2.2, encourage students to look up sine-bar constants from a reliable source such as the Machinery's Handbook.

C. Suggested supplemental materials

1. Oberg, Erik; Franklin D. Jones; Holbrook L. Horton. Machinery's Handbook. 23rd ed. New York: Industrial Press Inc., 1988.

2. "Handy Multipliers & Trigonometry Tables for Engineers." St. Louis: Carr Lane Mfg. Co., 1987. (Available from Carr Lane, 4200 Carr Lane Court, 63119; 314/647-6200)

MODULE: PERFORMING MATHEMATICAL CALCULATIONS

UNIT VI: RIGHT TRIANGLES

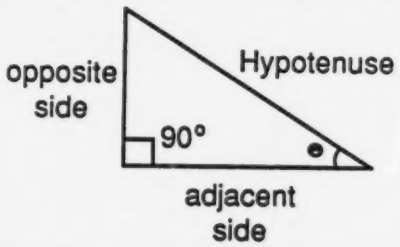
LESSON 1: TRIGONOMETRY

I. Terms and definitions

A. Adjacent side--side of a right triangle which is next to the measured angle

B. Hypotenuse--right triangle side which is opposite the right angle

C. Opposite side--side of a right triangle which is opposite or across from the measured angle



D. Right triangle--three-sided figure that has a right angle (90°)

E. Trigonometry--study of the trigonometric functions which express the relationships between the sides and angles of right triangles

II. Definition of trigonometric functions **(TM 1.1, HO 1.1, 1.2)**

A. There are six functions used in right triangle trigonometry.

1. Functions are the ratios between the various sides of a right triangle.

2. Trigonometric functions are very valuable because if two dimensions of a right triangle are known, all the other dimensions can be determined.

3. Trigonometric functions are ratios which are the same for a given angle for all triangles; values of trigonometric functions can be found in trigonometric tables.

B. Definitions

1. Sine (sin)

$$\text{Sine of an angle} = \frac{\text{length of the opposite side}}{\text{length of the hypotenuse}}$$

2. Cosine (cos)

$$\text{Cosine of an angle} = \frac{\text{length of adjacent side}}{\text{length of hypotenuse}}$$

3. Tangent (tan)

$$\text{Tangent of an angle} = \frac{\text{length of opposite side}}{\text{length of adjacent side}}$$

4. Cotangent (cot)

   Cotangent of an angle = $\frac{\text{length of adjacent side}}{\text{length of opposite side}}$

5. Secant (sec)

   Secant of an angle = $\frac{\text{length of hypotenuse}}{\text{length of adjacent side}}$

6. Cosecant (csc)

   Cosecant of an angle = $\frac{\text{length of hypotenuse}}{\text{length of opposite side}}$

NOTE: Tan and cot are reciprocals, sin and csc are reciprocals, and cos and sec are reciprocals.

III. Determining the value of trigonometric functions

A. Scientific calculators can compute trigonometric functions.

1. Calculator saves time and reduces errors.

2. Enter the angle in decimal degrees, then press the desired function key.

B. Most tables give values to four decimal places. Most values are irrational numbers and are nonrepeating, nonterminating decimals.

C. Finding the value of a function of a certain angle in a table of trigonometric values

1. Locate the degrees and minutes on the edge of the table.

   a. If the degrees are less than 45°, find them on the left edge of the table.

   b. If the degrees are greater than 45°, find them on the right edge of the table.

2. Locate the function column.

   a. Locate the function column on the top of the table if the degrees are less than 45°.

   b. Locate the function column at the table's bottom if the degrees are more than 45°.

3. Read the value of the function in the degrees row and the function column.

   Example: Find the tangent of 89°. Find 89° on the right edge. Find the tan column at the bottom of the table. Tan 89° = 57.29

D. Interpolation for degrees not in the table.

1. Often it is necessary to find the function of an angle measured in minutes and seconds which is not in a table.

2. To determine the value, one must interpolate.

   a. First, find the values of the functions of the next highest and next lowest degrees in the table.

   b. Determine the difference between these two function values.

c. Determine the fraction of the difference for the unknown degrees and multiply this fraction times the difference found in step b.

d. Add to the function value of the next lowest degree.

e. Repeat steps c and d to determine the amount to add for the seconds.

Example: Determine the tangent of 15°37'17".

Step 1: Locate the tangents for 15°30' and 15°40'. (tan 15°30' = 0.27732, tan 15°40' = 0.28046)

Step 2: 0.28046 - 0.27732 = 0.00314

Step 3: 37' is 7/10 of the difference. (.7 x 0.00314 = 0.00220)

Step 4: tan 15°37' = 0.27732 + 0.00220 = 0.27952

Step 5: 17" is 17/600 more of the distance between the two values. (Each second is 1/600th [60 x 10 minutes] of the distance between the two values.)

17/600 x 0.00314 = 0.00009

tan 15°37'	= 0.27952
	+ 0.00009
tan 15°37'17"	= 0.27961

E. Inverse interpolation from function value to degrees, minutes and seconds

Example: Find x if sin x = 0.7231. From the table, sin x is between sin 46°10' (0.7214) and sin 46°20' (0.7234). The difference between the known functions is 0.7234 - 0.7214 = 0.0020. The difference between the unknown function and the lower value is 0.7231 - 0.7214 = 0.0017. Therefore sin x is 17/20 of the distance between the two known values, and 17/20 x 600 (the degrees difference in seconds) = 510 seconds or 8' 30".

The answer is 46°10' + 8'30" = 46°18'30".

F. Functions of obtuse angles (angles greater than 90° and less than 180°)

1. sin angle x = sin (180° - angle x)

2. cos angle x = -cos (180° - angle x)

3. tan angle x = -tan (180° - angle x)

IV. Solution of right angle triangles

A. Finding the length of the side opposite a known angle

1. When the length of the hypotenuse is known

a. Multiply the hypotenuse by the sine of the angle.

b. Or divide the hypotenuse by the cosecant of the angle.

2. When the length of the side adjacent is known

a. Multiply the side adjacent by the tangent of the angle.

b. Or divide the side adjacent by the cotangent of the angle.

B. To find the length of the side adjacent to a known angle

1. When the length of the hypotenuse is known

a. Multiply the hypotenuse by the cosine of the angle.

b. Or divide the hypotenuse by the secant of the angle.

2. When the length of the side opposite is known

a. Multiply the side opposite by the cotangent of the angle.

b. Or divide the side opposite by the tangent of the angle.

C. To find the length of the hypotenuse

1. When the length of the side opposite the angle is known

a. Multiply the side opposite by the cosecant of the angle.

b. Or divide the side opposite by the sine of the angle.

2. When the length of the side adjacent the angle is known

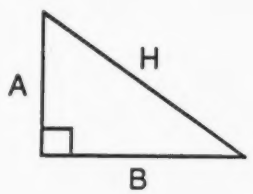
a. Multiply the side adjacent by the secant of the angle.

b. Divide the side adjacent by the cosine of the angle.

V. Pythagorean Theorem

A. The Pythagorean Theorem is used to find a side when the other two sides are known.

B. In any right angle triangle, the square of the hypotenuse equals the sum of the squares of the other two sides.

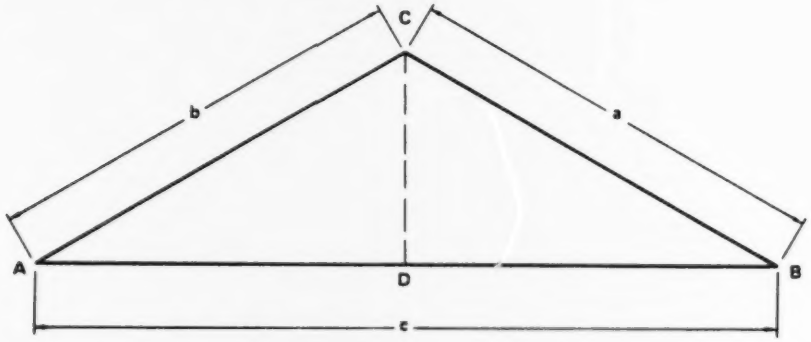


$H^2 = A^2 + B_2$

C. By rearranging the formula, $A^2 = H^2 - B^2$ and $B_2 = H^2 - A^2$.

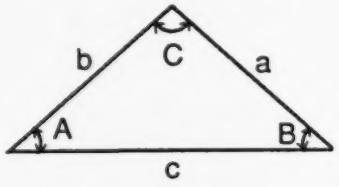
VI. Solving oblique triangles which contain no right angles

A. Dimensions of oblique triangles are determined by drawing perpendicular lines to make right triangles and then using ratios.



Credit: Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., © 1988. Reproduced by permission.

B. The law of sines: The sides of any triangle (right and oblique) are proportional to the sines of the opposite angles.



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \quad \text{or}$$

$$\frac{\sin A}{\sin B} = \frac{a}{b} \qquad \frac{\sin A}{\sin C} = \frac{a}{c} \qquad \frac{\sin B}{\sin C} = \frac{b}{c}$$

C. Law of cosines: In any triangle, the square of any side is equal to the sum of the squares of the other two sides minus twice the product of these sides and the cosine of the angle included between them.

1. $a^2 = b^2 + c^2 - 2bc(\cos A)$ or $\cos A = \frac{b^2 + c^2 - a^2}{2bc}$

2. $b^2 = a^2 + c^2 - 2ac(\cos B)$ or $\cos B = \frac{a^2 + c^2 - b^2}{2ac}$

3. $c^2 = a^2 + b^2 - 2ab(\cos C)$ or $\cos C = \frac{a^2 + b^2 - c^2}{2ab}$

D. The sides and angles of any triangle can be determined if any three parts (angles or sides) are known.

1. Two angles and one side are known.

   a. The third angle can be determined by using the fact that the sum of the angles is 180°.

b. Use the law of sines to find each of the remaining sides.

2. Two sides and the angle opposite one of them are known.

   a. Use the law of sines to find the unknown angle opposite a given side.

   b. Find the third angle by subtraction from 180°.
   c. Find the third side by using the law of sines again.

   NOTE: Under certain conditions, two distinct triangles (two solutions) can exist with the same three given parts.

3. Two sides and the included angle are known.

   a. Use the law of cosines to find the third side.

   b. Find the second angle using the law of sines and the third by subtraction.

4. The three sides are known.

   a. Use the law of cosines to find each of the angles.

   b. As a check, add the degrees of all of the angles. (The sum should be 180°.)

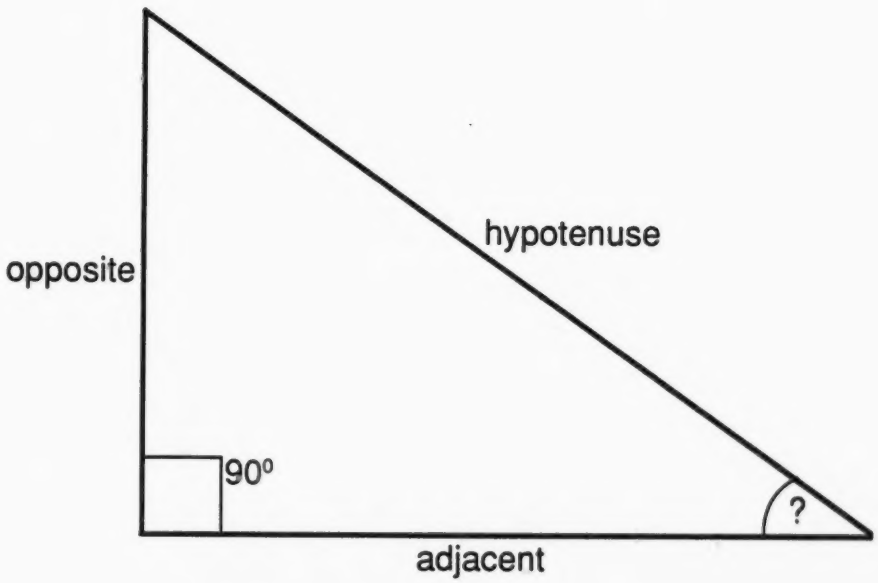
TRIG. MEMORY AID

"Oscar has a heap of apples"

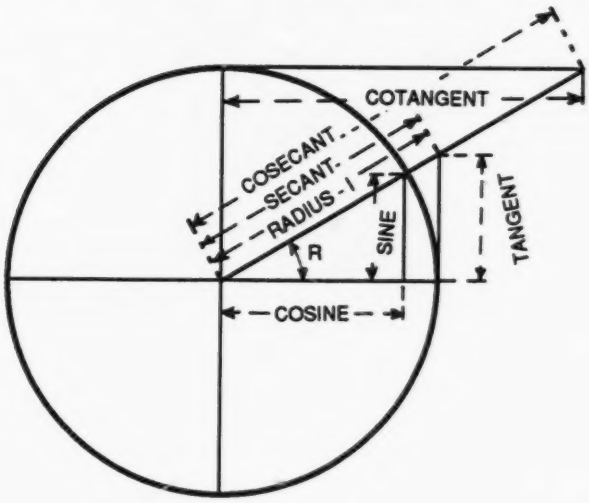
$$\text{sine} = \frac{O}{H}$$

$$\text{cosine} = \frac{A}{H}$$

$$\tan = \frac{O}{A}$$



RIGHT ANGLE FORMULAS



Formulas for finding functions of angles

SINE = $\frac{\text{Side opposite}}{\text{Hypotenuse}}$

COSINE = $\frac{\text{Side adjacent}}{\text{Hypotenuse}}$

TANGENT = $\frac{\text{Side opposite}}{\text{Side adjacent}}$

COTANGENT = $\frac{\text{Side adjacent}}{\text{Side opposite}}$

SECANT = $\frac{\text{Hypotenuse}}{\text{Side adjacent}}$

COSECANT = $\frac{\text{Hypotenuse}}{\text{Side opposite}}$

Formulas for finding the length of sides for right-angle triangles (when an angle and side are known)

Length of hypotenuse
- Side opposite x cosecant
- Side opposite ÷ sine
- Side adjacent x secant
- Side adjacent ÷ cosine

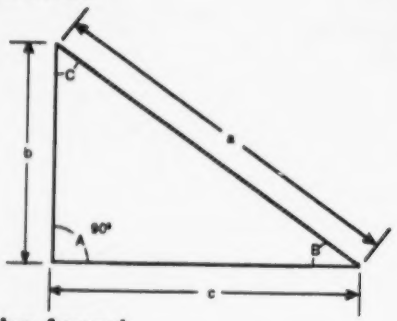
Length of side opposite
- Hypotenuse x sine
- Hypotenuse ÷ cosecant
- Side adjacent x tangent
- Side adjacent ÷ cotangent

Length of side adjacent
- Hypotenuse x cosine
- Hypotenuse ÷ secant
- Side opposite x cotangent
- Side opposite ÷ tangent

SOLUTION OF RIGHT-ANGLED TRIANGLES

As shown in the illustration, the sides of the right-angled triangle are designated *a, b* and *c*. The angles opposite each of these sides are designated *A, B* and *C*, respectively.

Angle *A* opposite the hypotenuse *a* is the right angle and is therefore always one of the known quantities.



Sides and angles known	Formulas for sides and angles to be found		
Sides a and b	$c = \sqrt{a^2 - b^2}$	$\sin B = \frac{b}{a}$	$C = 90° - B$
Sides a and c	$b = \sqrt{a^2 - c^2}$	$\sin C = \frac{c}{a}$	$B = 90° - C$
Sides b and c	$a = \sqrt{b^2 + c^2}$	$\tan B = \frac{b}{c}$	$C = 90° - B$
Side a; angle B	$b = a \times \sin B$	$c = a \times \cos B$	$C = 90° - B$
Side a; angle C	$b = a \times \cos C$	$c = a \times \sin C$	$B = 90° - C$
Side b; angle B	$a = \frac{b}{\sin B}$	$c = b \times \cot B$	$C = 90° - B$
Side b; angle C	$a = \frac{b}{\cos C}$	$c = b \times \tan C$	$B = 90° - C$
Side c; angle B	$a = \frac{c}{\cos B}$	$b = c \times \tan B$	$C = 90° - B$
Side c; angle C	$a = \frac{c}{\sin C}$	$b = c \times \cot C$	$B = 90° - C$

Credit: Adapted from "Handy Multipliers & Trigonometry Tables for Engineers." St. Louis: Carr Lane Mfg. Co., 1987.

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
0° 00′	.00000	1.0000	.00000	infinite	1.0000	infinite	90° 00′
10′	.00291	1.0000	.00291	343.77	1.0000	343.77	50′
20′	.00582	.99998	.00582	171.88	1.0000	171.89	40′
30′	.00873	.99996	.00873	114.59	1.0000	114.59	30′
40′	.01164	.99993	.01164	85.940	1.0001	85.946	20′
50′	.01454	.99989	.01455	68.750	1.0001	68.757	10′
1° 00′	.01745	.99985	.01746	57.290	1.0001	57.299	89° 00′
10′	.02036	.99979	.02036	49.104	1.0002	49.114	50′
20′	.02327	.99973	.02328	42.964	1.0003	42.976	40′
30′	.02618	.99966	.02619	38.189	1.0003	38.201	30′
40′	.02908	.99958	.02910	34.368	1.0004	34.382	20′
50′	.03199	.99949	.03201	31.242	1.0005	31.257	10′
2° 00′	.03490	.99939	.03492	28.636	1.0006	28.654	88° 00′
10′	.03781	.99929	.03783	26.432	1.0007	26.450	50′
20′	.04071	.99917	.04075	24.542	1.0008	24.562	40′
30′	.04362	.99905	.04366	22.904	1.0009	22.925	30′
40′	.04653	.99892	.04658	21.470	1.0011	21.494	20′
50′	.04943	.99878	.04949	20.206	1.0012	20.230	10′
3° 00′	.05234	.99863	.05241	19.081	1.0014	19.107	87° 00′
10′	.05524	.99847	.05533	18.075	1.0015	18.103	50′
20′	.05814	.99831	.05824	17.169	1.0017	17.198	40′
30′	.06105	.99813	.06116	16.350	1.0019	16.380	30′
40′	.06395	.99795	.06408	15.605	1.0020	15.637	20′
50′	.06685	.99776	.06700	14.924	1.0022	14.958	10′
4° 00′	.06976	.99756	.06993	14.301	1.0024	14.335	86° 00′
10′	.07266	.99736	.07285	13.727	1.0026	13.763	50′
20′	.07556	.99714	.07578	13.197	1.0029	13.235	40′
30′	.07846	.99692	.07870	12.706	1.0031	12.745	30′
40′	.08136	.99668	.08163	12.251	1.0033	12.291	20′
50′	.08426	.99644	.08456	11.826	1.0036	11.868	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
5° 00′	.08716	.99619	.08749	11.430	1.0038	11.474	85° 00′
10′	.09005	.99594	.09042	11.059	1.0041	11.104	50′
20′	.09295	.99567	.09335	10.712	1.0043	10.758	40′
30′	.09585	.99540	.09629	10.385	1.0046	10.433	30′
40′	.09874	.99511	.09923	10.078	1.0049	10.127	20′
50′	.10164	.99482	.10216	9.7882	1.0052	9.8391	10′
6° 00′	.10453	.99452	.10510	9.5144	1.0055	9.5668	84° 00′
10′	.10742	.99421	.10805	9.2553	1.0058	9.3092	50′
20′	.11031	.99390	.11099	9.0098	1.0061	9.0651	40′
30′	.11320	.99357	.11394	8.7769	1.0065	8.8337	30′
40′	.11609	.99324	.11688	8.5556	1.0068	8.6138	20′
50′	.11898	.99290	.11983	8.3450	1.0071	8.4046	10′
7° 00′	.12187	.99255	.12278	8.1444	1.0075	8.2055	83° 00′
10′	.12476	.99219	.12574	7.9530	1.0079	8.0156	50′
20′	.12764	.99182	.12869	7.7704	1.0082	7.8344	40′
30′	.13053	.99144	.13165	7.5958	1.0086	7.6613	30′
40′	.13341	.99106	.13461	7.4287	1.0090	7.4957	20′
50′	.13629	.99067	.13758	7.2687	1.0094	7.3372	10′
8° 00′	.13917	.99027	.14054	7.1154	1.0098	7.1853	82° 00′
10′	.14205	.98986	.14351	6.9682	1.0102	7.0396	50′
20′	.14493	.98944	.14648	6.8269	1.0107	6.8998	40′
30′	.14781	.98902	.14945	6.6912	1.0111	6.7655	30′
40′	.15069	.98858	.15243	6.5606	1.0115	6.6363	20′
50′	.15356	.98814	.15540	6.4348	1.0120	6.5121	10′
9° 00′	.15643	.98769	.15838	6.3138	1.0125	6.3924	81° 00′
10′	.15931	.98723	.16137	6.1970	1.0129	6.2772	50′
20′	.16218	.98676	.16435	6.0844	1.0134	6.1661	40′
30′	.16505	.98629	.16734	5.9758	1.0139	6.0588	30′
40′	.16792	.98580	.17033	5.8708	1.0144	5.9554	20′
50′	.17078	.98531	.17333	5.7694	1.0149	5.8554	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

TRIGONOMETRIC FUNCTIONS (cont'd)

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
10° 00′	.17365	.98481	.17633	5.6713	1.0154	5.7588	80° 00′
10′	.17651	.98430	.17933	5.5764	1.0159	5.6653	50′
20′	.17937	.98378	.18233	5.4845	1.0165	5.5749	40′
30′	.18224	.98325	.18534	5.3955	1.0170	5.4874	30′
40′	.18509	.98272	.18835	5.3093	1.0176	5.4026	20′
50′	.18795	.98218	.19136	5.2257	1.0181	5.3205	10′
11° 00′	.19081	.98163	.19438	5.1446	1.0187	5.2408	79° 00′
10′	.19366	.98107	.19740	5.0658	1.0193	5.1636	50′
20′	.19652	.98050	.20042	4.9894	1.0199	5.0886	40′
30′	.19937	.97992	.20345	4.9152	1.0205	5.0158	30′
40′	.20222	.97934	.20648	4.8430	1.0211	4.9452	20′
50′	.20507	.97875	.20952	4.7729	1.0217	4.8765	10′
12° 00′	.20791	.97815	.21256	4.7046	1.0223	4.8097	78° 00′
10′	.21076	.97754	.21560	4.6383	1.0230	4.7448	50′
20′	.21360	.97692	.21864	4.5736	1.0236	4.6817	40′
30′	.21644	.97630	.22169	4.5107	1.0243	4.6202	30′
40′	.21928	.97566	.22475	4.4494	1.0249	4.5604	20′
50′	.22212	.97502	.22781	4.3897	1.0256	4.5021	10′
13° 00′	.22495	.97437	.23087	4.3315	1.0263	4.4454	77° 00′
10′	.22778	.97371	.23393	4.2747	1.0270	4.3910	50′
20′	.23062	.97304	.23700	4.2193	1.0277	4.3362	40′
30′	.23345	.97237	.24008	4.1653	1.0284	4.2836	30′
40′	.23627	.97169	.24316	4.1126	1.0291	4.2324	20′
50′	.23910	.97100	.24624	4.0611	1.0299	4.1824	10′
14° 00′	.24192	.97030	.24933	4.0108	1.0306	4.1336	76° 00′
10′	.24474	.96959	.25242	3.9617	1.0314	4.0859	50′
20′	.24756	.96887	.25552	3.9136	1.0321	4.0394	40′
30′	.25038	.96815	.25862	3.8667	1.0329	3.9939	30′
40′	.25320	.96742	.26172	3.8208	1.0337	3.9495	20′
50′	.25601	.96667	.26483	3.7760	1.0345	3.9061	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
15° 00′	.25882	.96593	.26795	3.7321	1.0353	3.8637	75° 00′
10′	.26163	.96517	.27107	3.6891	1.0361	3.8222	50′
20′	.26443	.96440	.27419	3.6471	1.0369	3.7816	40′
30′	.26724	.96363	.27732	3.6059	1.0377	3.7420	30′
40′	.27004	.96285	.28046	3.5656	1.0386	3.7031	20′
50′	.27284	.96206	.28360	3.5261	1.0394	3.6651	10′
16° 00′	.27564	.96126	.28675	3.4874	1.0403	3.6279	74° 00′
10′	.27843	.96046	.28990	3.4495	1.0412	3.5915	50′
20′	.28123	.95964	.29305	3.4124	1.0420	3.5559	40′
30′	.28402	.95882	.29621	3.3759	1.0429	3.5209	30′
40′	.28680	.95799	.29938	3.3402	1.0438	3.4867	20′
50′	.28959	.95715	.30255	3.3052	1.0448	3.4532	10′
17° 00′	.29237	.95630	.30573	3.2709	1.0457	3.4203	73° 00′
10′	.29515	.95545	.30891	3.2371	1.0466	3.3881	50′
20′	.29793	.95459	.31210	3.2041	1.0476	3.3565	40′
30′	.30071	.95372	.31530	3.1716	1.0485	3.3255	30′
40′	.30348	.95284	.31850	3.1397	1.0495	3.2951	20′
50′	.30625	.95195	.32171	3.1084	1.0505	3.2653	10′
18° 00′	.30902	.95106	.32492	3.0777	1.0515	3.2361	72° 00′
10′	.31178	.95015	.32814	3.0475	1.0525	3.2074	50′
20′	.31454	.94924	.33136	3.0178	1.0535	3.1792	40′
30′	.31730	.94832	.33460	2.9887	1.0545	3.1515	30′
40′	.32006	.94740	.33783	2.9600	1.0555	3.1244	20′
50′	.32282	.94646	.34108	2.9319	1.0566	3.0977	10′
19° 00′	.32557	.94552	.34433	2.9042	1.0576	3.0715	71° 00′
10′	.32832	.94457	.34758	2.8770	1.0587	3.0458	50′
20′	.33106	.94361	.35085	2.8502	1.0598	3.0206	40′
30′	.33381	.94264	.35412	2.8239	1.0608	2.9957	30′
40′	.33655	.94167	.35740	2.7980	1.0619	2.9713	20′
50′	.33929	.94068	.36068	2.7725	1.0630	2.9474	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
20° 00′	.34202	.93969	.36397	2.7475	1.0642	2.9238	70° 00′
10′	.34475	.93869	.36727	2.7228	1.0653	2.9006	50′
20′	.34748	.93769	.37057	2.6985	1.0664	2.8778	40′
30′	.35021	.93667	.37388	2.6746	1.0676	2.8554	30′
40′	.35293	.93565	.37720	2.6511	1.0688	2.8334	20′
50′	.35565	.93462	.38053	2.6279	1.0699	2.8117	10′
21° 00′	.35837	.93358	.38386	2.6051	1.0711	2.7904	69° 00′
10′	.36108	.93253	.38721	2.5826	1.0723	2.7694	50′
20′	.36379	.93148	.39055	2.5605	1.0736	2.7488	40′
30′	.36650	.93042	.39391	2.5387	1.0748	2.7285	30′
40′	.36921	.92935	.39727	2.5172	1.0760	2.7085	20′
50′	.37191	.92827	.40065	2.4960	1.0773	2.6888	10′
22° 00′	.37461	.92718	.40403	2.4751	1.0785	2.6695	68° 00′
10′	.37730	.92609	.40741	2.4545	1.0798	2.6504	50′
20′	.37999	.92499	.41081	2.4342	1.0811	2.6316	40′
30′	.38268	.92388	.41421	2.4142	1.0824	2.6131	30′
40′	.38537	.92276	.41763	2.3945	1.0837	2.5949	20′
50′	.38805	.92164	.42105	2.3750	1.0850	2.5770	10′
23° 00′	.39073	.92050	.42447	2.3559	1.0864	2.5593	67° 00′
10′	.39341	.91936	.42791	2.3369	1.0877	2.5419	50′
20′	.39608	.91822	.43136	2.3183	1.0891	2.5247	40′
30′	.39875	.91706	.43481	2.2998	1.0904	2.5078	30′
40′	.40141	.91590	.43828	2.2817	1.0918	2.4912	20′
50′	.40408	.91472	.44175	2.2637	1.0932	2.4748	10′
24° 00′	.40674	.91355	.44523	2.2460	1.0946	2.4586	66° 00′
10′	.40939	.91236	.44872	2.2286	1.0961	2.4426	50′
20′	.41204	.91116	.45222	2.2113	1.0975	2.4269	40′
30′	.41469	.90996	.45573	2.1943	1.0989	2.4114	30′
40′	.41734	.90875	.45924	2.1775	1.1004	2.3961	20′
50′	.41998	.90753	.46277	2.1609	1.1019	2.3811	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
25° 00′	.42262	.90631	.46631	2.1445	1.1034	2.3662	65° 00′
10′	.42525	.90507	.46985	2.1283	1.1049	2.3515	50′
20′	.42788	.90383	.47341	2.1123	1.1064	2.3371	40′
30′	.43051	.90259	.47698	2.0965	1.1079	2.3228	30′
40′	.43313	.90133	.48055	2.0809	1.1095	2.3087	20′
50′	.43575	.90007	.48414	2.0655	1.1110	2.2949	10′
26° 00′	.43837	.89879	.48773	2.0503	1.1126	2.2812	64° 00′
10′	.44098	.89752	.49134	2.0353	1.1142	2.2676	50′
20′	.44359	.89623	.49495	2.0204	1.1158	2.2543	40′
30′	.44620	.89493	.49858	2.0057	1.1174	2.2411	30′
40′	.44880	.89363	.50222	1.9912	1.1190	2.2282	20′
50′	.45140	.89232	.50587	1.9768	1.1207	2.2153	10′
27° 00′	.45399	.89101	.50953	1.9626	1.1223	2.2027	63° 00′
10′	.45658	.88968	.51319	1.9486	1.1240	2.1902	50′
20′	.45917	.88835	.51688	1.9347	1.1257	2.1778	40′
30′	.46175	.88701	.52057	1.9210	1.1274	2.1657	30′
40′	.46433	.88566	.52427	1.9074	1.1291	2.1536	20′
50′	.46690	.88431	.52798	1.8940	1.1308	2.1418	10′
28° 00′	.46947	.88295	.53171	1.8807	1.1326	2.1300	62° 00′
10′	.47204	.88158	.53545	1.8676	1.1343	2.1185	50′
20′	.47460	.88020	.53920	1.8546	1.1361	2.1070	40′
30′	.47716	.87882	.54296	1.8418	1.1379	2.0957	30′
40′	.47971	.87743	.54673	1.8291	1.1397	2.0846	20′
50′	.48226	.87603	.55051	1.8165	1.1415	2.0735	10′
29° 00′	.48481	.87462	.55431	1.8041	1.1433	2.0627	61° 00′
10′	.48735	.87321	.55812	1.7917	1.1452	2.0519	50′
20′	.48989	.87178	.56194	1.7796	1.1471	2.0413	40′
30′	.49242	.87036	.56577	1.7675	1.1489	2.0308	30′
40′	.49495	.86892	.56962	1.7556	1.1508	2.0204	20′
50′	.49748	.86748	.57348	1.7438	1.1528	2.0101	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

TRIGONOMETRIC FUNCTIONS (cont'd)

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
30° 00′	.50000	.86603	.57735	1.7321	1.1547	2.0000	60° 00′
10′	.50252	.86457	.58124	1.7205	1.1566	1.9900	50′
20′	.50503	.86310	.58513	1.7090	1.1586	1.9801	40′
30′	.50754	.86163	.58904	1.6977	1.1606	1.9703	30′
40′	.51004	.86015	.59297	1.6864	1.1626	1.9606	20′
50′	.51254	.85866	.59691	1.6753	1.1646	1.9510	10′
31° 00′	.51504	.85717	.60086	1.6643	1.1666	1.9416	59° 00′
10′	.51753	.85567	.60483	1.6534	1.1687	1.9322	50′
20′	.52002	.85416	.60881	1.6426	1.1707	1.9230	40′
30′	.52250	.85264	.61280	1.6319	1.1728	1.9139	30′
40′	.52498	.85112	.61681	1.6213	1.1749	1.9048	20′
50′	.52745	.84959	.62083	1.6107	1.1770	1.8959	10′
32° 00′	.52992	.84805	.62487	1.6003	1.1792	1.8871	58° 00′
10′	.53238	.84650	.62892	1.5900	1.1813	1.8783	50′
20′	.53484	.84495	.63299	1.5798	1.1835	1.8697	40′
30′	.53730	.84339	.63707	1.5697	1.1857	1.8611	30′
40′	.53975	.84182	.64117	1.5597	1.1879	1.8527	20′
50′	.54220	.84025	.64528	1.5497	1.1901	1.8443	10′
33° 00′	.54464	.83867	.64941	1.5399	1.1924	1.8361	57° 00′
10′	.54708	.83708	.65355	1.5301	1.1946	1.8279	50′
20′	.54951	.83549	.65771	1.5204	1.1969	1.8198	40′
30′	.55194	.83389	.66189	1.5108	1.1992	1.8118	30′
40′	.55436	.83228	.66608	1.5013	1.2015	1.8039	20′
50′	.55678	.83066	.67028	1.4919	1.2039	1.7960	10′
34° 00′	.55919	.82904	.67451	1.4826	1.2062	1.7883	56° 00′
10′	.56160	.82741	.67875	1.4733	1.2086	1.7806	50′
20′	.56401	.82577	.68301	1.4641	1.2110	1.7730	40′
30′	.56641	.82413	.68728	1.4550	1.2134	1.7655	30′
40′	.56880	.82248	.69157	1.4460	1.2158	1.7581	20′
50′	.57119	.82082	.69588	1.4370	1.2183	1.7507	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
35° 00′	.57358	.81915	.70021	1.4282	1.2208	1.7434	55° 00′
10′	.57596	.81748	.70455	1.4193	1.2233	1.7362	50′
20′	.57833	.81580	.70891	1.4106	1.2258	1.7291	40′
30′	.58070	.81412	.71329	1.4020	1.2283	1.7220	30′
40′	.58307	.81242	.71769	1.3934	1.2309	1.7151	20′
50′	.58543	.81072	.72211	1.3848	1.2335	1.7081	10′
36° 00′	.58779	.80902	.72654	1.3764	1.2361	1.7013	54° 00′
10′	.59014	.80730	.73100	1.3680	1.2387	1.6945	50′
20′	.59248	.80558	.73547	1.3597	1.2413	1.6878	40′
30′	.59482	.80386	.73996	1.3514	1.2440	1.6812	30′
40′	.59716	.80212	.74447	1.3432	1.2467	1.6746	20′
50′	.59949	.80038	.74900	1.3351	1.2494	1.6681	10′
37° 00′	.60182	.79864	.75355	1.3270	1.2521	1.6616	53° 00′
10′	.60414	.79688	.75812	1.3190	1.2549	1.6552	50′
20′	.60645	.79512	.76272	1.3111	1.2577	1.6489	40′
30′	.60876	.79335	.76733	1.3032	1.2605	1.6427	30′
40′	.61107	.79158	.77196	1.2954	1.2633	1.6365	20′
50′	.61337	.78980	.77661	1.2876	1.2661	1.6303	10′
38° 00′	.61566	.78801	.78129	1.2799	1.2690	1.6243	52° 00′
10′	.61795	.78622	.78598	1.2723	1.2719	1.6182	50′
20′	.62024	.78442	.79070	1.2647	1.2748	1.6123	40′
30′	.62251	.78261	.79544	1.2572	1.2778	1.6064	30′
40′	.62479	.78079	.80020	1.2497	1.2807	1.6005	20′
50′	.62706	.77897	.80498	1.2423	1.2837	1.5947	10′
39° 00′	.62932	.77715	.80978	1.2349	1.2867	1.5890	51° 00′
10′	.63158	.77531	.81461	1.2276	1.2898	1.5833	50′
20′	.63383	.77347	.81946	1.2203	1.2929	1.5777	40′
30′	.63608	.77162	.82434	1.2131	1.2960	1.5721	30′
40′	.63832	.76977	.82923	1.2059	1.2991	1.5666	20′
50′	.64056	.76791	.83415	1.1988	1.3022	1.5611	10′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

TRIGONOMETRIC FUNCTIONS (cont'd)

Angles	Sin	Cos	Tan	Cot	Sec	Csc	Angles
40° 00′	.64279	.76604	.83910	1.1918	1.3054	1.5557	50° 00′
10′	.64501	.76417	.84407	1.1847	1.3086	1.5503	50′
20′	.64723	.76229	.84906	1.1778	1.3118	1.5450	40′
30′	.64945	.76041	.85408	1.1709	1.3151	1.5398	30′
40′	.65166	.75851	.85912	1.1640	1.3184	1.5345	20′
50′	.65386	.75661	.86419	1.1572	1.3217	1.5294	10′
41° 00′	.65606	.75471	.86929	1.1504	1.3250	1.5242	49° 00′
10′	.65825	.75280	.87441	1.1436	1.3284	1.5192	50′
20′	.66044	.75088	.87955	1.1369	1.3318	1.5141	40′
30′	.66262	.74896	.88473	1.1303	1.3352	1.5092	30′
40′	.66480	.74703	.88992	1.1237	1.3386	1.5042	20′
50′	.66697	.74509	.89515	1.1171	1.3421	1.4993	10′
42° 00′	.66913	.74314	.90040	1.1106	1.3456	1.4945	48° 00′
10′	.67129	.74120	.90569	1.1041	1.3492	1.4897	50′
20′	.67344	.73924	.91099	1.0977	1.3527	1.4849	40′
30′	.67559	.73728	.91633	1.0913	1.3563	1.4802	30′
40′	.67773	.73531	.92170	1.0850	1.3600	1.4755	20′
50′	.67987	.73333	.92709	1.0786	1.3636	1.4709	10′
43° 00′	.68200	.73135	.93252	1.0724	1.3673	1.4663	47° 00′
10′	.68412	.72937	.93797	1.0661	1.3710	1.4617	50′
20′	.68624	.72737	.94345	1.0599	1.3748	1.4572	40′
30′	.68835	.72537	.94896	1.0538	1.3786	1.4527	30′
40′	.69046	.72337	.95451	1.0477	1.3824	1.4483	20′
50′	.69256	.72136	.96008	1.0416	1.3863	1.4439	10′
44° 00′	.69466	.71934	.96569	1.0355	1.3902	1.4395	46° 00′
10′	.69675	.71732	.97132	1.0295	1.3941	1.4352	50′
20′	.69883	.71529	.97700	1.0236	1.3980	1.4310	40′
30′	.70091	.71325	.98270	1.0176	1.4020	1.4267	30′
40′	.70298	.71121	.98843	1.0117	1.4060	1.4225	20′
50′	.70505	.70916	.99420	1.0058	1.4101	1.4183	10′
45° 00′	.70711	.70711	1.0000	1.0000	1.4142	1.4142	45° 00′
Angles	Cos	Sin	Cot	Tan	Csc	Sec	Angles

HO 1.1 (cont.)

Credit: Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., © 1988. Reproduced by permission.

DEGREES AND FUNCTION VALUES

Determine the following functions.

1. Sine of 35° 24' 32" _____
2. Tangent of 47° 30' 45" _____
3. Cosine of 65° 0' 35" _____
4. Cotangent 50° 40' 15" _____
5. Sine 83° 45' _____
6. Sine 25° 26' _____

Determine the angles corresponding to each of the following values.

7. cos Y = 0.99182 _____
8. tan Y = 0.50587 _____
9. sin Y = 0.82577 _____
10. cot Y = 0.08163 _____
11. cos Y = 0.81111 _____

Determine the sine, cosine and tangent of the following angles.

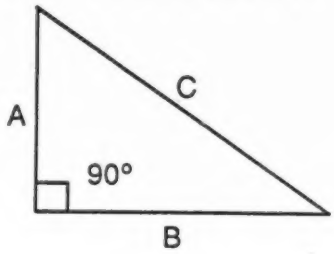
	Sine	Cosine	Tangent
12. 130°			
13. 125° 49' 15"			
14. 170° 45'			

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B12: Calculate measurements of right triangles.

DIMENSIONS AND ANGLES OF RIGHT TRIANGLES

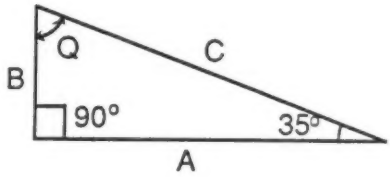
1. If a right triangle has a 35° angle, what size is the third angle?

Using the information given, determine the length of the third side.



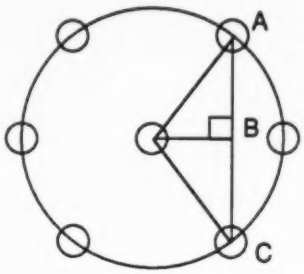
2. A = 45 mm; B = 12 mm _____
3. A = 1.3 yards; C = 4.67 yards _____
4. B = 6.234"; C = 9.345" _____
5. C = 205 mm; A = 187 mm _____

Use the figure below to answer the following questions.



6. How many degrees is angle Q? _____
7. If side C = 10", what is the length of side B? _____ What is the length of side A? _____
8. If side B = 4.5", what is the length of side C? _____ What is the length of side A? _____

Six holes are equally spaced around a 100 mm circle. Answer the questions that follow.



9. What size is angle AOC in degrees? _____

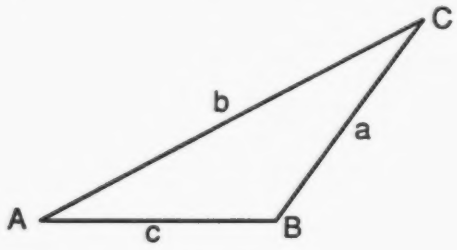
10. What size is angle AOB? _____

11. What are the lengths of the lines OA, OB and AC? _____

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B12: Calculate measurements of right triangles.

DIMENSIONS AND ANGLES OF OBLIQUE TRIANGLES

Using the laws of sines and/or cosines and the values given, find the missing values in the triangle below.



1. Side a = 45 mm, angle A = 43° and angle B = 100°. Find side b, side c and angle C.

2. Side b = 85.4 mm, angle A = 37° and angle C = 35°. Find side a, side c and angle B.

3. Angle A = 32°, angle C = 46° and side c = 15 mm. Find sides a and b and angle B.

4. Angle C = 28°, side c = 19 mm and side b = 22 mm. Find side a and angles A and B.

5. Angle B = 97°, side a = 36 mm and side c = 41 mm. Find side b and angles A and C.

6. Side a = 240 mm, side b = 330 mm and side c = 190 mm. Find all of the angles.

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B6: Calculate part and feature dimensions and locations.

ANSWERS TO AS 1.1

1. 0.57941
2. 1.0918
3. 0.42247
4. 0.81934
5. 0.99406
6. 0.42946
7. 7°20'
8. 26°50'
9. 55°40'
10. 85°20'
11. 35°47'42"
12. 0.76604, -0.64279, -1.1918
13. 0.80915, -0.58761, -1.3770
14. 0.18652, -0.98245, -0.18986

ANSWERS TO AS 1.2

1. 55°
2. C = 47 mm
3. B = 4.5 yards
4. A = 6.962"
5. B = 84 mm
6. a. 55°
7. B = 5.7", A = 8.2"
8. C = 7.8", A = 6.4"
9. 120°
10. 60°
11. 50 mm, 25 mm, 86.6 mm

ANSWERS TO AS 1.3

1. b = 65 mm, c = 40 mm, Angle C = 37°
2. a = 54.0 mm, c = 51.5 mm, Angle B = 108°
3. a = 11 mm, b = 20 mm, Angle B = 102°
4. a = 3.5 mm or 35 mm, Angle A = 5° or 119°, Angle B = 33° or 147°
5. b = 51 mm, Angle A = 44°, Angle C = 39°
6. Angle A = 46°, Angle B = 99.5°, Angle C = 34.5°

MODULE: PERFORMING MATHEMATICAL CALCULATIONS

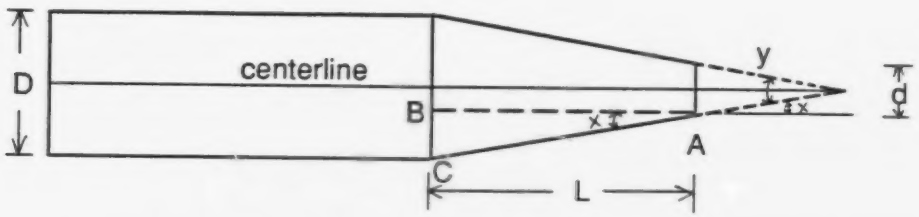
UNIT VI: RIGHT TRIANGLES

LESSON 2: TRIGONOMETRY APPLICATIONS

I. Determining the angle of a taper

A. When the angle of a taper is not known, it can be determined using trigonometry.

B. Determining the included angle of a taper (angle A)



1. Draw a line (AB) parallel to the center line which intersects the corner of the workpiece. This forms right triangle ABC.

2. The value of line AB = L or the length of the taper.

3. The value of line BC equals the large diameter minus the small diameter divided by two.

4. Using the tan function, tan angle x = $\frac{BC}{AB}$

5. Compound rests are set for the angle determined.

6. If a taper attachment is used, it should be set for the included angle. The included angle (Y) is twice the angle determined.

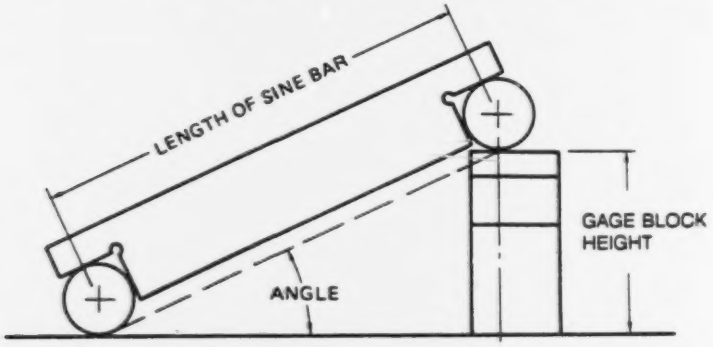
   Example: Determine the angle of a taper on a workpiece whose diameter is 1" and tip diameter is 1/2". The taper length is 3/4".

   $$\tan x = \frac{0.25"}{0.75"} = 0.3333$$

   From the tables and using inverse interpolation, angle x is 18°25' 56".

II. Using the sine bar

A. The sine bar is a tool used with gage blocks to precisely measure, check or construct angles.



Credit: Hoffman, Edward G., and Dennis D. Davis. Practical Problems in Mathematics for Machinists. 3rd ed. Albany, NY: Delmar Publishers Inc., © 1988. Reproduced by permission.

B. Usual trigonometric calculations can be used to do computations. However, formulas and sine-bar constant tables simplify calculations.

C. Sine bars are usually 5" long, although some are 10" long. Metric sine bars are also available.

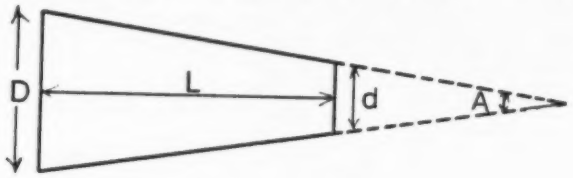
D. Formulas

1. Sine of the angle = $\frac{\text{gage block height}}{\text{length of the sine bar}}$

2. Gage block height = sine of angle x length of sine bar

TAPER-ANGLE CALCULATIONS

Determine the included angle (A) to the nearest second for the taper dimensions given.



1. D = 110 mm, d = 75 mm, L = 300 mm A = _____
2. D = 1.25", d = 0.75", L = 1" A = _____
3. D = 90 mm, d = 50 mm, L = 350 mm A = _____
4. D = 2.14 cm, d = 1.11 cm, L = 3 cm A = _____
5. D = 5 cm, d = 0.66 cm, L = 15.1 cm A = _____

Assume that the included angle A of the taper illustrated above is 24°. Determine the larger diameter D for each of the lengths L and d. (Calculate to the nearest ten-thousandth inch.)

6. L = 3", d = 1.5" D = _____
7. L = 5", d = 2.1" D = _____
8. L = 6", d = 0.5" D = _____

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency B9: Calculate tapers for machine set-up.

SINE-BAR CALCULATIONS

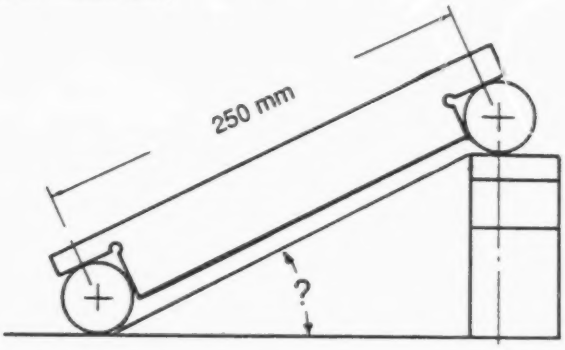
Using a scientific calculator and the sine-bar constant table for a 5" sine bar from Machinery's Handbook, determine the needed gage block height for the following angles. (Round to the nearest ten-thousandth inch.)

1. 36°15'
2. 26°42'
3. 37°9'

For the following gage block heights, determine the angle formed by a 10" sine bar. (Determine angles to the nearest minute.)

4. 3.07"
5. 2.8"
6. 2.090"
7. 2.672"

What stack height is required to check the angles given below, using a 250 mm sine bar? (Express answers to the nearest hundredth millimeter.)



8. 52° 16'
9. 65° 24'
10. 25° 30'

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competencies B10: Calculate sine-bar set-up and D7: Use Machinery's Handbook to plan work.

ANSWERS TO AS 2.1

1. 6° 40' 38"
2. 28° 4' 20"
3. 6° 32' 28"
4. 19° 28' 54"
5. 16° 21' 20"
6. 2.7754"
7. 4.2256"
8. 3.0507"

ANSWERS TO AS 2.2

1. 2.9566"
2. 2.2466"
3. 3.0195"
4. 17° 53'
5. 16° 16'
6. 12° 4'
7. 15° 30'
8. 197.70 mm
9. 227.31 mm
10. 107.63 mm

MODULE: PERFORMING MATHEMATICAL CALCULATIONS

UNIT VI: RIGHT TRIANGLES

UNIT TEST

NOTE: A trigonometric table or calculator with trigonometric functions will be needed to complete this test.

Match definitions on the left with terms on the right.

____ 1. The side opposite the right angle

____ 2. Ratio of the side opposite an angle to the hypotenuse of a right triangle

____ 3. Ratio of the side opposite an angle to the side adjacent an angle in a right triangle

____ 4. Ratio of the side adjacent an angle to the hypotenuse in a right triangle

____ 5. Inverse of the cosine function

____ 6. Inverse of the sine function

____ 7. Used to find the side of a right triangle when the other two sides are known

____ 8. The ratios of sides to sines of opposite angles are proportional in any triangle

____ 9. Used to find a side of any triangle when two sides and the included angle are known

a. Pythagorean Theorem
b. Tangent
c. Secant
d. Cosine
e. Law of sines
ab. Law of cosines
ac. Hypotenuse
ad. Cosecant
ae. Sine

Choose the best answer to each question or problem.

____ 10. If the sine of 40° is 0.64279, 41° is 0.65606, and 40° 10' is 0.64501, what is the sine of 40° 5'?

a. 0.6439
b. 0.6494
c. 0.6432
d. 0.6430
e. 0.6461

____ 11. To determine the sine of 100°, _____ .

a. Look for 100° on the left side of the table
b. Look for 100° on the right side of the table
c. Find the sine of 80°
d. Find the sine of 10°
e. Find the cosine of 10°

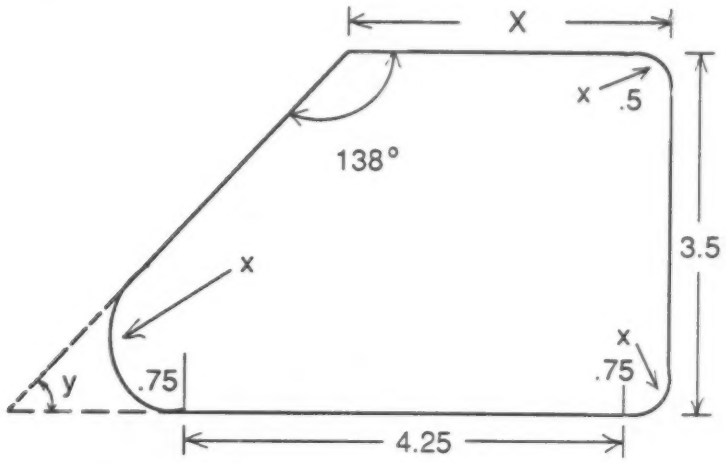
____ 12. If the hypotenuse of a right triangle is 9 cm and one of the sides is 4 cm, how long is the third side?

a. 2.24 cm
b. 3.61 cm
c. 8.06 cm
d. 9.85 cm
e. 65 cm

____ 13. How long is the hypotenuse of a right triangle which has sides that are 5" and 7"?

a. 4.9"
b. 6"
c. 8.6"
d. 65"
e. 74"

Use the following diagram for #14 and 15.



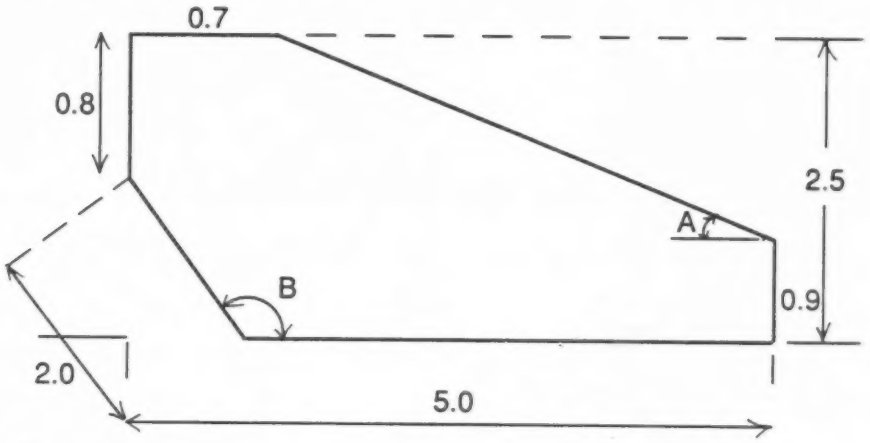
____ 14. Determine angle y.

a. 15°
b. 30°
c. 32°
d. 42°
e. 52°

____ 15. Determine distance X.

a. 3.06
b. 3.89
c. 4.00
d. 4.25
e. 4.31

Use the following diagram for #16 and 17.



___ 16. Determine angle A.

a. 17.75°
b. 18.75°
c. 20.5°
d. 21.25°
e. 69°

___ 17. Determine angle B.

a. 31.45°
b. 58.25°
c. 69.5°
d. 110.5°
e. 121.75°

___ 18. Determine the included angle of a taper when the length is 200 mm and the diameters are 100 mm and 50 mm.

a. 7.25°
b. 14.5°
c. 26.5°
d. 53°
e. 82.5°

___ 19. If using a 5" sine bar, how high must the gage block be for a 31° angle?

a. 0.1030"
b. 0.4286"
c. 2.575"
d. 4.286"
e. 9.708"

___ 20. If using a 10" sine bar, how high must the gage block be for a 31° angle?

a. 0.8572
b. 0.8572"
c. 4.286"
d. 5.150"
e. 25.752"

ANSWERS TO UNIT TEST

1.	ac	(B12)	11.	c	(B12)
2.	ae	(B12)	12.	c	(B12)
3.	b	(B12)	13.	c	(B12)
4.	d	(B12)	14.	d	(B6)
5.	c	(B12)	15.	a	(B6)
6.	ad	(B12)	16.	c	(B6)
7.	a	(B12)	17.	e	(B6)
8.	e	(B12)	18.	b	(B9)
9.	ab	(B12)	19.	c	(B10)
10.	a	(B12)	20.	d	(B10)